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# Co-ordinated studies in view of the future round of multilateral trade negotiations in the agriculture and food sector. Final consolidated report

Chantal Le Mouël

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**FAIR5-CT97-3481**

**"Co-ordinated Studies in View of the Future Round of Multilateral Trade Negotiations  
in the Agriculture and Food Sector"**

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**FINAL CONSOLIDATED REPORT**

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**INRA-Economie et Sociologie Rurales, Rennes**

**September 2001**

**participants:**

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INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE (France), ESR, Toulouse

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## PREFACE

The final consolidated report of the programme "co-ordinated studies in view of the future round of multilateral trade negotiations in the agriculture and food sector" is the last deliverable of a project which started in March 1998.

At that moment, the common view was that both the commitments agreed upon in 1994, within the Uruguay Round Agreement on Agriculture (URAA), and the next round of multilateral trade negotiations, scheduled to start by the end of year 1999, would be likely to impose further constraints on the Common Agricultural Policy (CAP) and require additional adjustments in Common Market Organisations (CMOs). This is in that context that this programme started with the aim of co-ordinating a task force working on the preparation of the coming round of multilateral negotiations under the auspices of the World Trade Organisation (WTO).

The main purpose of the project was to provide a set of studies, in connection with policymakers, involving a comprehensive economic analysis of the main issues of the next round of multilateral negotiations, as well as their consequences for the future of the CAP, and quantitative assessments of the likely effects of WTO proposals on the European Union (EU) agriculture.

Such a purpose gave the project a somewhat specific status. On the one hand, it was clear since the beginning that the proposed analyses would be policy-oriented and that the task force involved would work closely with EU decision makers. To this regard, one very positive aspect of the project is that it has benefited, during its overall lifetime, of the sustained following and support from the DG Agriculture. On the other hand, as a FAIR programme, the project should not be limited to market and policy expert evaluation but also include genuine research work. It was therefore for all partners a challenge to develop analytical tools, based on economic theory, which outcomes would be directly useful for EU trade negotiators and decision makers.

The financing by the European Commission has allowed us to design a set of tools and to carry out work for making them relevant to analyse the main issues of multilateral negotiations, their consequences in terms of CAP reforms and the effects of various policy options for EU agriculture. Provided tools are different in nature. They include databases, synthetic indicators, theoretical models and applied simulation models. The financing by the European Commission also made it possible to co-ordinate our efforts in using these tools for providing policymakers with sound economic and policy-oriented analyses, with a view to support trade negotiations and assist planning in the EU agricultural and food sector.

This consolidated report presents methodologies used, models developed and main findings per research task.

Finally, as co-ordinator of the project, I want to thank the European Commission for financing this research. I hope that the outcome is meeting the expectations and that our results are useful for EU trade negotiators and policymakers. I also want to express my gratitude to DG Agriculture for the help and support we benefited all along the project's life. I am particularly indebted to Marina Mastrostefano for her constant following. Her involvement and her active contribution to our meetings as well as to our work have constituted an invaluable support for the co-ordinator in leading this project through to a successful conclusion. Moreover her kindness and her sustained encouragement were a great help for the co-ordinator in doubtful moments.

Lastly, I would like to thank involved partners. The good finalisation of this project relies on their excellent scientific contributions. I greatly thank all researchers and assistants that have participated to this project for the sizeable and high-quality work they have carried out.

## INTRODUCTION

### *The background to the FAIR5-CT97-3481 programme*

The FAIR5-CT97-3481 programme started on the beginning of 1998. At that time, the consequences of the basic provisions of the Uruguay Round Agreement on Agriculture (URAA) for the European Union (UE) and the Common Agricultural Policy (CAP) were well documented in the literature (e.g., Josling and Tangermann, 1992; Guyomard and Mahé, 1993; Helmar et al., 1994; Guyomard et al., 1996; Swinbank, 1996; Tangermann, 1996). And all existing studies agreed that the major constraint the AAUR would impose on EU agriculture would lie in the export commitments. The commitments to reduce domestic support would impose no adjustment needs on the CAP because of the accommodating treatment of AMS (Aggregate Measure of Support) reductions, in particular the exclusion of 1992 CAP reform compensatory payments from AMS computation. In the same way, tariffication of border measures and the new access provisions in the form of current access and minimum access tariff quotas would marginally improve the price competitiveness of imports into the EU over the six-year implementation period.

The common view however was that, although the immediate quantitative effects of the URAA on EU agriculture would likely to be modest, its significance should not be underestimated. In fact, "recognising that the long-term objective of substantial progressive reductions in support and protection resulting in fundamental reform is an ongoing process", Article 20 of the Agreement includes a commitment to engage in a new round of multilateral agricultural negotiations before the end of 1999. Thus, the placement of agriculture on the agenda of multilateral negotiations and the definition of a negotiation framework in the form of three main areas, i.e., internal support, market access and export competition, are two features of major significance of the URAA (Vanzetti, 1996).

Then, at the beginning of 1998, it was expected that the next round of World Trade Organisation (WTO) talks (the so-called Millenium Round) would use again the negotiation framework of the Uruguay Round and that the proponents of reform (particularly the United States and the Cairns group) would push for further commitments in terms of internal support reduction, market access improvement and export subsidy cut. In addition, by announcing that all the support provided to farmers under the Federal Agriculture Improvement and Reform Act of 1996 would qualify for the so-called "green" box, the United States (US) had indicated their willingness to challenge the exemption of a large share of EU farm support from reduction commitment (the so-called "blue box" issue). On the other hand, the mandate given to the US Trade Representative by the Agriculture and Food Consultative Committee suggested that EU internal regulations relative to competition, norms, quality standards, etc would likely to be challenged in the Millenium Round.

From the EU perspective, it was expected that not only the URAA commitments would probably require a significant adjustment of European agriculture around the year 2000, but the next round of WTO negotiations would be likely to impose further constraints on the CAP, and require larger changes in Common Market Organisations (European Commission, 1997; FAPRI, 1998; USDA, 1998; OECD, 1999).

***The objectives of the FAIR5-CT97-3481 programme***

In that context, the aim of the FAIR5-CT97-3481 programme was to co-ordinate a task force working on the preparation of the Millennium Round. The purpose of the programme was to provide a set of studies, in connection with policymakers, involving:

- comprehensive economic analyses of the main issues of the next round of multilateral negotiations;
- databases and indicators on trade and tariffs for the EU as well as other major trading countries;
- assessments of the world market environment and prices as well as of the forecasted effects of WTO reform proposals;
- quantitative assessments of the economic impact of WTO proposals on EU agriculture, including simulations on reforms of Common Market Organisations (CMOs) which could be necessary to comply with these proposals;
- assessments of the effects of proposed "regulatory reforms" on the EU agro-food industry, with special attention paid to the trade effects of food standards and food labelling.

More specifically, the following operational objectives have been retained:

1. Assess the current international trade environment, which will form the basis of the next round of multilateral negotiations.
2. Develop effective measures of trade restrictions, encompassing domestic support as well as tariffs and non-tariff measures such as food safety and quality standards, and develop effective measures of decoupled domestic support.
3. Evaluate the impact of trade reforms on world markets and, in turn, the implications for European agriculture and the food processing industries.
4. Assess the degree to which food safety and quality standards act as impedance to trade and the implications of regulatory reforms on trade flows.

5. Define an appropriate classification of Non-Tariff Barriers (NTBs) which assesses the degree to which such measures impede trade and/or actually address market failures, which can be applied to assess the impact of regulatory reforms.

6. Overall, to provide a comprehensive analysis of policy reforms and trade in agriculture and food products within the European Union to support future trade negotiations and aid planning in the agricultural and food sectors.

### ***Presentation of tasks and subtasks***

In order to achieve the above-mentioned objectives, the research has been organised into three tasks, further divided into subtasks to facilitate effective management. For each task or subtask, a co-ordinator has been appointed who was responsible for the methodology, co-ordination and final analysis (see Table 1.1).

**Table 1.1. Tasks, subtasks and co-ordinators**

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- **Task 1:** Analysis of the international trade environment for agricultural and food products
    - Subtask 1.1: Development of a database on trade (**co-ordinator: partner 2, INRA-ESR Grignon**)
    - Subtask 1.2: Constructing indicators of trade restriction, measures of protection and support, and assessing the consequences of choosing a particular indicator (**co-ordinator: Partner 1, INRA-ESR Rennes**)
    - Subtask 1.3: Assessing the development of the world market environment and world market prices using a revised and updated version of the TRADE model (**co-ordinator: partner 3, University of Bonn**)
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- **Task 2:** Quantitative assessments of the economic impact of policy reforms on agriculture and the food sector in the European Union
    - Subtask 2.1: Arable crops (**co-ordinator: partner 1, INRA-ESR Rennes**)
    - Subtask 2.2: Dairy (**co-ordinator: partner 5, University of Wageningen**)
    - Subtask 2.3: Beef (**co-ordinator: partner 1, INRA-ESR Rennes**)
    - Subtask 2.4: Wine (**co-ordinator: partner2, INRA-ESR Grignon**)
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- **Task 3:** Effect of proposed agreements in the area of regulatory reform on the EU agro-food industry (**co-ordinator: partner 4, University of Reading**)
    - Stage 1: Survey of regulatory requirements
    - Stage 2: Interviews
    - Stage 3: Postal survey
    - Stage 4: Estimation of market effects
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### *Additional background elements during the course of the FAIR5-CT97-3481 programme*

Since the beginning of 1998, two main features have marked the background to the FAIR5-CT97-3481 programme. First of all, in March 1999, the EU adopted a CAP reform package (Agenda 2000). This reform basically extends the 1992 reform and introduces more decoupling in the system of compensatory payments to COP (cereals, oilseeds and protein crops) producers. The Agenda 2000 reform was largely motivated by EU export commitments under the AAUR and the expectation that these commitments would be strengthened in the Millenium Round (Desquilbet et al., 1999). However, smoothing the EU East enlargement process and easing CAP budget pressures were also important concerns supporting the Agenda 2000 reform.

Secondly, in December 1999, the Seattle ministerial conference marked the opening of the Millenium Round. The first phase of multilateral negotiations (which ended in March 2001) has consisted of countries submitting proposals containing their starting position for the negotiations. Hence, since the early 2000, 125 WTO member governments have submitted 45 proposals from which it is possible to deduce the issues that are likely to be the major focus of the second phase of negotiations.

The synthesis of the overall received proposals provided by the WTO Secretariat (WTO, 2001) globally confirms the main issues that were expected at the beginning of the FAIR5-CT97-3481 programme. On the market access side, further tariff reductions should be negotiated, but how the reductions will be handled is still undecided and appears as a major negotiating area. It is widely recognised that the Uruguay Round (UR) calculated equivalent tariffs were very often too high to allow real opportunity for imports. Hence, the discussion is likely to focus on various ways to define and apply reduction rates, for market protection to be effectively reduced.<sup>1</sup> Regarding tariff-rate quotas (TRQs) there are several proposals for either replacing them with low tariffs or increasing their size, but at the moment the discussion almost turns on quota administration. Many countries advocate for increased scrutiny of methods used for giving exporters access to quotas. They add that it should be clarified which methods are legal or illegal under WTO rules. On the export competition side, as expected further reductions in export subsidies should be negotiated. Currently, some countries propose the total elimination of export subsidies while others are prepared to negotiate further progressive reductions. Finally, on the domestic support side, the received proposals deal with the three "boxes". As expected further reduction of "amber box" measures should be negotiated. As in the case of tariffs, how this additional reduction will be applied seems to be a major concern in discussions. To this regard, some countries advocate that ceilings should be set for specific products rather than having overall aggregated ceilings. Proposals dealing with the "green box" are of three

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<sup>1</sup> The US for example proposes that the negotiations to reduce tariffs starts with applied tariffs instead of generally higher corresponding bound tariffs.

types. Unsurprisingly, some countries push for increased scrutiny of measures currently included, arguing that some of them, in certain circumstances, could have an influence on production and prices. Others think that the "green box" should not be changed because it is already satisfactory. The last ones argue for a broadening of the "green box" to cover additional types of measures. Finally, as expected, some countries want the "blue box" to be scrapped because it involves payments that are only partly decoupled from production. Obviously, some other countries oppose scrapping it completely and maintain that the "blue box" is an important tool for supporting and reforming agriculture, and for achieving certain "non-trade" objectives.

The synthesis of proposals by the WTO Secretariat points out a certain number of other issues. These were also expected issues at the beginning of the FAIR5-CT97-3481 programme. However, we paid lower attention to them when developing this programme. This is the case of, mainly, the extension of the export subsidy discipline to all forms of subsidies (including the effect of state trading enterprises, food aid and export credits) as well as "non-trade" concerns and multifunctionality.

All these additional background elements, which punctuated the programme's life, did not make us to depart from the original plan. However, they contributed, in the finalisation stage, to bend the work undertaken for integrating them into our analyses. Thus, as far as the Agenda 2000 reform is concerned, we decided when defining the reference runs of all developed models, that they should include this CAP change. It results that, within both subtask 1.3 and task 2, the analyses carried out with, respectively, the world trade (the so-called WATSIM) model and the EU sectoral models for arable crops, dairy and beef start with an examination of the impacts of the Agenda 2000 reform package in each of these EU sectors.

Secondly, the proposals submitted by countries to the WTO oriented our work in mainly two areas. On the one hand, they helped us to specify the policy scenarios to be simulated with the various models. Hence, within subtask 1.3, we retained, as a stylised liberalisation scenario, a policy scenario replicating the main provisions of the URAA, which in view of the submitted proposals appears as a possible outcome of the Millenium Round. Furthermore, as submitted proposals confirm that the decoupling issue will be a major focus of the Millenium Round, this issue being of key importance for the future of the CAP, we decided to integrate the decoupling dimension in most of our simulated scenarios. Therefore, still within task 1.3, all simulated scenarios that were originally designed assuming coupled CAP direct payments have been supplemented by alternative scenarios assuming a greater degree of decoupling of these payments. In the same vein, within task 2, some policy scenarios have been defined in order to shed some light on the degree of decoupling of the Agenda 2000 CAP direct payment systems. On the other hand, following the growing debate around multifunctionality in

WTO submitted proposals, we oriented our last work undertaken on decoupling within subtask 1.2 towards this issue.

### ***Outline of the report***

In chapter 1, methodologies used for the different subtasks are described. Chapter 2 refers to subtask 1.1 and deals with the database on tariffs and trade. The modalities adopted to construct this database as well as its content are first described. Then, a thorough assessment of the implementation of the Uruguay Round market access discipline is provided. Chapter 3 refers to subtask 1.2 and focuses on market protection indicators. Using the Trade Restrictiveness Index (TRI) and the Mercantilist Trade Restrictiveness Index (MTRI), a comparison of EU and US tariff structures before and after the URAA implementation is proposed. This allows to assess and compare the improvement in market access that was permitted in both countries by the Uruguay Round commitments on tariffs. In addition, the effects of the actual URAA commitments are compared to alternative schemes of tariff reductions such as the "Swiss formula" and the uniform tariff reduction. This makes it possible to assess and compare the impact of the uneven allocation of tariff cuts across commodities implemented by the EU and the US under the URAA. Chapter 4 also refers to subtask 1.2 and is concerned with the decoupling issue. The first part of the analysis gives an overview of the main advantages and limits of decoupling. The second part deals with the "green box" decoupling criteria as defined in Annex 2 of the URAA. Two theoretical models are developed in order to compare the degree of decoupling of various internal income support instruments, and in so doing to examine whether the corresponding "green box" decoupling criteria are well-designed. Using an extended version of one of the above-mentioned theoretical models, the last part of the analysis addresses the question of the relative merits of traditional income support instruments as regards to the promotion of multifunctionality. Chapter 5 refers to subtask 1.3 and reports the analyses carried out with the WATSIM (World Agricultural Trade SIMulation) model. Firstly, a detailed description of the model is provided. Secondly, the reference run of the model is presented and analysed, emphasising the likely developments of the world market environment, as the background to the Millenium Round. Thirdly, the results of a stylised liberalisation scenario, as a fictitious outcome of the Millenium Round, are described and discussed.

Chapters 2 and 5 contribute to the first objective of the programme (assess the current international trade environment which will form the basis of the next round of multilateral negotiations). Chapters 3 and 4 are devoted to the second objective of the programme (develop effective indicators of trade restrictions and develop effective measures of decoupled domestic support). The third objective of the programme (evaluate the impact of trade reforms on world markets and their implications for European agriculture and the food processing industries) is dealt with in the last part of chapter 5 and in the following chapters 6 to 10.

Chapter 6 refers to subtask 2.1 and reports the analysis carried out with the EU sectoral model for arable crops. Chapters 7 and 8 both refer to subtask 2.2. Chapter 7 is concerned with the model of the EU's dairy and beef producing sector and related policy simulations. While chapter 8 concentrates on the model of the EU's milk processing sector and related performed simulations. Chapter 9 refers to subtask 2.3 and focuses on the analysis carried out with the EU sectoral model for beef. Finally, chapter 10 refers to subtask 2.4 and addresses the question of the welfare effects of an Appellation of Origin using a software depicting a regional market regulated through an Appellation of Origin. In all these chapters, the model developed is presented first. Then, the reference run of the model is described and the obtained results are discussed. Finally, alternative simulations performed with the model are proposed and results are analysed. In chapters 6 to 9, alternative simulations corresponds to policy change scenarios, while in chapter 10 they involve changes in some characteristics of the regional market considered.

Chapters 11 and 12 both refer to task 3. The assessment of the impact of technical measures (or standards) on EU agricultural and food exports to the United-States is the subject of chapter 11. The chapter starts with an analysis and a review of literature centred on the definition and the classification of technical measures, the impact of such measures on trade, the available methods for quantifying this impact and the existing studies devoted to estimate this impact in the context of trade in agricultural and food products. Then, the impact of US technical measures on EU agricultural and food exports to the US is assessed combining various methods. Chapter 12 focuses on the economics of non-tariff barriers. It proposes several analytical frameworks allowing to analyse the welfare effects of domestic food quality and safety regulations and to examine their ability to address market failures. A particular attention is paid to market failures resulting from risk and imperfect information.

Chapter 11 contributes to the fourth objective of the programme (assess the degree to which food safety and quality standards hinder trade, and the implications of regulatory reform on trade flows). Chapter 12 relates to the fifth objective of the programme (define an appropriate classification of non-tariff barriers that assesses the degree to which such measures impede trade and/or actually address market failures).

The overall report contribute to the sixth objective of the programme (to provide a comprehensive analysis of domestic policies and trade reforms in agriculture and food products in the EU, with a view to support future trade negotiations and to assist planning in the agricultural and food sector).



## **1 - MATERIAL AND METHODS**

As indicated in the introduction, the research was divided into three tasks, further divided into eleven subtasks (or stages, as far as task 3 is concerned). In this report, results of these eleven subtasks are reported in chapters 2 to 12. However for purpose of rationalising the presentation, one chapter does not necessarily correspond to one subtask, even if this is most often the case. In fact, when one subtask contributes to several objectives or, at reverse, when several subtasks contribute to the same objective, results are presented according to the objectives rather than according to the subtask they refer to. As there is an obvious relationship between material and methods used and pursued objectives, applied methodologies for this project are described following the framework of chapters 2 to 12.

It is important to emphasise that in next sections, material and methods used are described without going into too much details since further descriptions are provided in each of chapters 2 to 12.

### **1.1. The database on tariffs, tariff-rate quotas (TRQs) and trade (chapter 2)**

Subtask 1.1 consists in the development of a database on tariffs and trade. The database has been constructed with the principle of matching all the relevant information to each country's official schedule on bound tariffs, as submitted under the URAA.

As a result, the developed database is organised on the basis of the 8-digit Harmonised System (HS) classification, for chapters 01, 02, 03 to 24 (that is, all food products with the exception of fisheries products), and for selected items of chapters 29, 31, 35, 38, 40, 41, 50, 51 and 52 (that is, non-food agricultural products, such as skins for leather, etc). This introduced a lot of difficulty for gathering the relevant information, since the list of commodities include some 2800 items.

The database has been constructed for a set of countries, namely Australia, Brazil, Canada, the EU, Japan, Korea, Norway and the US. Datasets have been completed in a satisfactory way for Canada, the EU and the US. For other countries, datasets remained flawed because of problems in the correspondence between the various sources of information. It was decided then, together with the Commission's representatives, to focus on the Canada, the EU and the US, and to provide less sophisticated data for other countries.

Hence, for Canada, the EU and the US, the constructed datasets include, in addition to the schedules on base (1995) and bound tariffs (2000), import values, import quantities, unit values of imports (under and out of the Most Favoured Nation status) and applied tariffs, for each year since 1995. Moreover, as during the project's life the Commission's representatives highlighted the fact that the

tariff-rate quotas (TRQs) are an important issue in the WTO negotiations, TRQ information have been added to countries' datasets.

For the EU, data sources are mainly COMEXT for import values and quantities, and both the TARIC and the UNCTAD's TRAINS databases for applied tariffs. Furthermore, obtained applied tariffs were checked against the applied tariffs published in the Official Journal of the European Communities. For the US, trade and tariff data come mainly from the USITC (US International Trade Commission) database, while for Canada most of the data are extracted from the Statistics Canada database. Finally, for all three countries, the main sources for information on TRQS are the URAA schedules as well as notifications that were obtained from the WTO Secretariat.

### **1.2. Market access indicators (chapter 3)**

The part of subtask 1.2 devoted to market access is aimed at constructing indicators of trade restriction and, on the basis of these indicators, assessing and comparing the improvement in market access that was permitted in the UE and other countries by the URAA.

This part of subtask 1.2 has been carried out by first conducting a thorough review of literature on available methods to measure market protection. Relying on this review, the approach proposed by Anderson and Neary, which develops theoretically consistent measures in terms of a given criterion of equivalence among trade barriers, has been retained. More specifically, two indicators have been retained : i) the TRI (Trade Restrictiveness Index), which corresponds to the uniform tariff equivalent in terms of welfare (Anderson and Neary, 1994) and ii) the MTRI (Mercantilistic Trade Restrictiveness Index), representing the uniform tariff equivalent in terms of imports (Anderson and Neary, 1999), and which might be more relevant regarding trade negotiations.

The second step corresponds to the empirical implementation of the TRI and the MTRI in order to assess and compare the change in market access in the EU and other countries due to the URAA. Because the empirical estimation of indicators such as the TRI and the MTRI is very demanding in terms of data and parameter requirement, it was decided to focus on the EU and the US.

The analysis involves three stages. Firstly, the rates of change of the UE and US TRI and MTRI between 1995 and 2000 are computed using the base and bound tariffs of both countries as submitted under the URAA. This first stage allows to assess and to compare how much liberalisation was achieved in both countries by the end of the implementation period of the URAA, compared to the initial situation. Secondly, the rates of change of the EU and US TRI and MTRI between 1995 and 2000 are computed using two other schemes of tariff reduction: the "Swiss formula" and the uniform tariff reduction. In the case of the "Swiss formula", the resulting changes in the TRI and MTRI reflect

the impact of tariff reduction commitments that would have focused more on reducing tariff dispersion than the actual URAA tariff cuts. For the uniform tariff reduction, the resulting changes in the TRI and MTRI measure the impact of tariff reduction commitments that would have focused more on reducing tariff average than the actual URAA commitments. Hence, this second stage allows to assess and to compare the impact of the uneven allocation of tariff cuts across commodities implemented by the EU and the US under the URAA. Thirdly, the levels of the EU and US MTRI are computed for the years 1995 and 2000, using the same three schemes of tariff reduction than within the second stage. This third stage adds information on the EU and US tariff structures at the beginning and at the end of the URAA implementation period.

Prices, base and bound tariffs and import quantities required for computing the EU and US TRI and MTRI were extracted from the database on tariffs and trade developed within subtask 1.1. Regarding tariffs, for some commodities the EU and US schedules include a combination of ad-valorem and specific tariffs, with sometimes thresholds on one or both tariff components. Therefore, specific components were converted into ad-valorem equivalents by using the average 1995-1998 unit value of imports (or exports when imports were not available, or a unit value of the most similar commodity as a proxy when there was no trade in any of the four years). When tariff lines mentioned a threshold, the highest possible tariffs were considered.

Data on total expenditures were taken from the GTAP (Global Trade Project Analysis) database (version 4, Mc Dougall et al., 1998).

EU and US import elasticities were estimated econometrically. The estimation of these parameters raises a lot of problems, so that simplifying assumptions had to be adopted. First of all required data for a sufficiently long period were available only at the level of the so-called SITC classification (from the OECD's NEXT database), which is more aggregated than the 8-digit HS level. Hence, import elasticities were estimated for the commodity aggregates of the SITC classification. Consequently the single elasticity estimate of each aggregate was attributed to all 8-digit level commodities composing the corresponding aggregate. Secondly, due to the very large number of considered commodities, the specification of import demand functions as well as the estimation procedure had to be simplified. Thus, import demand functions were specified in double log form, with the domestic own price (unit value) of imports deflated by the domestic consumer price index and the domestic real income as the only explanatory variables. In other words, cross price effects were not taken into account, which is clearly a limitation of the study. Finally, import demand functions were estimated over the period 1973-1996 using the OLS method.

Due to these adopted simplifying assumptions, the estimated elasticities for any particular commodity can obviously only be considered as very crude estimates. Hence a sensitivity analysis has been

conducted in order to check how responsive are the TRI and MTRI estimates to the magnitudes of import demand elasticities.

### **1.3. The decoupling issue (chapter 4)**

The part of subtask 1.2 devoted to internal support is aimed at contributing to the debate on the decoupling of internal support instruments and the related WTO "green box" definition.

The analysis starts with a thorough review of literature on decoupling. Based on the general theory of welfare economics, the theoretical foundations of the principle of decoupling are reviewed. Then, the main limits of this principle when applied to domestic agricultural sectors and policies are discussed. These limits mainly relate to practical concerns and efficiency concerns. On the practical side, the different mechanisms through which internal support policy instruments affect production and trade are reviewed. From the economic efficiency point of view, the question is raised of the efficiency of highly decoupled policy instruments when concerned domestic economies are far removed from the theoretical first-best economies and when objectives assigned to agricultural policies are not confined to supporting agricultural incomes. This last point directly refers to the question of the multifunctionality of agriculture.

The second step of the analysis addresses the issue of the measurement of the degree of decoupling of internal support policy instruments and of the consistency of the "green box" decoupling criteria as defined in Annex 2 of the URAA. The analysis is focused on income support policy instruments and on corresponding "green box" decoupling criteria (i.e., point 6 of Annex 2). This part of the analysis is carried out by developing two different theoretical frameworks allowing to determine the effects on domestic production and trade of various income support policy instruments.

The first model is directed at emphasising the key role of production technologies and factor mobility assumptions as regards to the effects on domestic production (i.e., the degree of decoupling) of alternative income support policy instruments. The proposed model, inspired from Hertel (1989), considers two mono-product agricultural sectors, each using an aggregate variable input whose price is exogenous, a specific factor and a factor whose price is endogenous. Both sectors are competing for this last factor which is alternatively considered as homogeneous and perfectly mobile or heterogeneous and so imperfectly mobile between sectors. Comparative static results allow to show how the effects of policy instruments on domestic production are sensitive to adopted assumptions on production technologies and factor mobility. They are also used to check whether specific decoupling criteria of point 6 of Annex 2 of the URAA are well-designed.

The second model has as its aim to examine the effects of various income support policy instruments on domestic production and trade when both the number of farmers and the price of land are endogenous. The proposed model, inspired from both Hughes (1980) and Leathers (1992), considers one mono-product agricultural sector and consists in three equilibrium equations: the equilibrium condition in the output market, the equilibrium condition in the land market and the entry/exit condition. Comparative static results allow to compare the degree of decoupling of alternative policy instruments.

Finally, the third step of the analysis extends the second step by taking into account the multifunctional dimension of agriculture. More specifically, the second model is extended for allowing to examine the effects of income support policy instruments not only on domestic production and trade (i.e., their distortion effects) but also on indicators (such as farmers' profit, the number of farmers or yields) relating to various objectives that may be assigned to agricultural policies. In that case, comparative static results are derived on a constant cost/support basis, which allows it to classify instruments according to their relative ability to achieve each policy objective while minimising induced trade distortion effects.

#### **1.4. Assessing the world market environment: The WATSIM model (chapter 5)**

Subtask 1.3 is aimed at assessing the international trade environment, which will form the basis of the Millennium Round, and the impacts of trade reforms on world agricultural markets and trade.

This subtask has been carried out using a revised version of the WATSIM (World Agricultural Trade SIMulation) model. WATSIM is a partial equilibrium, multi-region and multi-commodity simulation model of the world agricultural markets and trade. The current version covers 10 countries and regional aggregates accounting for the whole world. For each region, 29 commodities are included, covering 4 cereals, starchy products, sugar, pulses, 4 oilseeds, 4 vegetable oils, 4 oil cakes, 4 meats, eggs, milk and 3 dairy products. The model is a comparative static framework. Starting from the 1997 base year situation, it is solved for a given set of target years, with no information given on the path of adjustment between base and target years. Most parameters used to describe supply and demand behaviours are not estimated but borrowed from other models or literature. All parameters are subject to careful calibration to meet microeconomic theory.

The initial version of the model has been revised with respect to two main areas. On the one hand its original net trade representation has been changed to now consider endogenously gross imports and gross exports on a same market. On the other hand, and based on the gross trade approach, the model's representation of tariff barriers and export subsidies has been improved. In addition, tariff-rate quotas (TRQs), that have become particularly relevant since the URAA, are now explicitly modelled.

The implementation of the gross trade approach within the WATSIM model has been conducted in two stages. Firstly, the former WATSIM database has been updated and adapted to the new gross trade structure of the model. The new WATSIM database consists now in two subsets: the former non-spatial database and the spatial database. The non-spatial database brings together data from various sources on production, demand, trade and prices of agricultural commodities, macroeconomic and sectoral data as well as policy data. It includes long time series, covering the period 1961-1997 (with some series extending up to 1999), available at the single country level for some 110 agricultural commodities. Programming routines have been developed, that allow to easily and quickly check for data consistency as well as aggregate data according to the model's regional and commodity structure. Available time series are extracted mainly from the FAOSTAT (FAO of the United Nations) and PSD (Production, Supply and Distribution, USDA) databases, the World Development Indicators (World Bank's database), the World Population Prospects (United Nations) and the Producer and Consumer Support Estimates (OECD).

The spatial database has been developed by adding bilateral trade flows and prices between the model's regions to the non-spatial database. The spatial database includes time series covering the period 1988-1997, available at the model's regional and commodity aggregate levels. Required bilateral trade flows are extracted mainly from the COMTRADE database (United Nations Statistics Division). A major task in the construction of the spatial database was to ensure consistency within this database and compared with the non-spatial database. The experience shows that the "double reporting" in bilateral trade flows statistics (i.e., importer quotation and exporter quotation) does not necessarily yields in mutual confirmation. In addition, in our specific case, the added gross imports and exports data (issued from the COMTRADE database) did not necessarily match the resulting net trade data of the non-spatial database (issued from mainly the FAOSTAT and PSD databases). Therefore, in order to ensure data consistency, the WATSIM spatial database has been constructed using an entropy-based approach, namely the cross-entropy approach (Golan et al., 1996).

The second stage consisted in the re-designing of the WATSIM model in order to incorporate gross trade representation. Based on the Armington assumption (Armington, 1969), import demand functions and export supply functions have been specified for each geographical zone and each commodity. Such functions closely rely on elasticities of, respectively, substitution and transformation. Due to data restrictions and resources limitations, these parameters have been "guesstimated". So, sensivity analyses aimed at investigating the impact of the adopted levels of these elasticities on the model outcome were carried out.

Since the new version of the WATSIM model represents explicitly gross imports and gross exports, it became possible to improve the modelling of trade policy instruments such as import tariff barriers,

TRQs and export subsidies. In very general terms, for each country and commodity, domestic "incentive prices" and import prices are linked to the corresponding world price through linear price transmission functions. Specific and ad-valorem tariffs are represented by simple linear elements in transmission functions from world to domestic import prices. Flexible levies are also explicitly modelled. They lead to non-differentiable price transmission functions. Thus, the exact relationship is smoothly approximated in order to allow for solubility. Just like import tariffs, export subsidies are specified as an element of price transmission functions on the export side. They can either be represented by a linear element or reflect a minimum domestic export price. In this last case, flexible export subsidies are modelled in a way similar to flexible levies on the import side. In addition, limits on subsidised exports are explicitly taken into account. For that purpose, two endogenous adjustment options are introduced in the model solution: in the case of a minimum export price, the model forces administrated stock purchases to adjust for subsidised exports do not exceed the corresponding limit; in the case of a constant export subsidy, the model forces the per-unit export subsidy to adjust for subsidised exports meet the bound. Lastly, TRQs are represented through two-tiered tariff lines: preferential tariffs for within quota imports and MFN (Most Favoured Nation) tariffs for over quota imports. The effective tariff (i.e., real protection) is then determined endogenously. It is at the preferential tariff level as long as the quota is unfilled, at the MFN tariff level when over quota imports occur and between both tariffs when the quota is just binding. This effective tariff function is non-differentiable and is approximated through smooth sigmoid functions.

### **1.5. MECOP: A model of the EU's producing sector of cereals, oilseeds and protein crops (chapter 6)**

The main objective of subtask 2.1 is to develop a sectoral model of arable crops for the EU in order to provide quantitative assessments of the impacts of reform proposals of the Common Market Organisation (CMO) for arable crops.

Subtask 2.1 has been carried out by developing a model of the EU's producing sector of cereals, oilseeds and protein crops (the so-called MECOP model) and then using this model for simulating alternative policy scenarios.

The MECOP (Maximum Entropy for Cereals, Oilseeds and Protein crops) model is centred on EU supply of cereals, oilseeds and protein crops (COP). A special feature of the model is that it considers explicitly the main policy instruments currently in force in the CMO for arable crops (i.e., price support, area payment system, set-aside requirement). A second distinctive feature of MECOP is that behavioural parameters are calibrated using the Generalised Maximum Entropy (GME) approach.

The MECOP model describes the supply behaviour of a representative COP producer. The specification of the model relies on duality theory in the presence of allocatable quasi-fixed factors. A multi-output restricted profit function where total land is fixed but allocatable to the various crops is defined. Then, via the envelope theorem, one obtains crop supply, variable input demand and land allocation functions. Using crop supply and land allocation functions, it is thus possible to derive yields per hectare functions. As the profit function incorporates the main policy instruments of the CMO for arable crops, these instruments are arguments of crop supply, variable input demand, land allocation and yields functions.

Hence, MECOP corresponds to a system of crop supply, variable input demand and land allocation equations. The functional form retained for the profit function to specify these equations is the normalised quadratic function. Behavioural parameters involved in these equations are calibrated using the GME approach (Golan et al., 1996). Data used for the calibration process (i.e., output quantities, cultivated areas devoted to each crop, total cultivated and idle areas, output and variable input prices and area payments) are time series covering the period 1973-1997, taken from the Eurostat CRONOS database and from the French joint-trade organisation ONIC (Office Interprofessionnel des céréales).

MECOP has been implemented at the national level for 6 EU Member States: Denmark, France, Germany, Italy, Spain and the United Kingdom. Ten crops have been retained: 6 cereals (soft wheat, barley, maize, durum wheat, oat and rye), 3 oilseeds (rape, sunflower and soya) and one protein crop (field peas). As the 6 above mentioned Member States are the main EU COP producing countries, MECOP nearly covers the overall EU15 supply for the retained crops.

#### **1.6. A model of the EU's dairy and beef producing sector (chapter 7)**

The main objective of subtask 2.2 is to develop a sectoral model of milk and dairy products for the EU in order to provide quantitative assessments of the impacts of reform proposals of the Common Market Organisation for milk and milk products.

Subtask 2.2 has been carried out by developing two models, which have then been used for simulating alternative policy scenarios. Both models depict the whole EU milk and dairy sector, but the first one is more specifically centred on the milk producing segment while the second one pays particular attention to the dairy processing segment. In addition, a supporting study aimed at estimating quota rent levels in the French dairy sector provided some empirical evidence for the calibration of initial quota rents in both models.

This section deals with the first model: the model of the EU's dairy and beef producing sector. The methodology used for the supporting study (reported in the appendix to chapter 7) is also briefly described.

The EU's dairy and beef producing sector depicts the supply behaviour of a representative dairy producer. However, an aggregate demand for milk is added. This allows the model to cover both the supply side and the demand side of the dairy sector, and almost to make the market price of milk endogenous following certain policy changes such as a quota removal for example.

A special feature of the model, on the supply side, is that dairy and beef production are fully integrated in the model, both as regards to the underlying decision making model and in specifying the constraints and trade-offs between the two types of production. The specification of the model relies on duality theory in the presence of output constraints. A restricted profit function where the milk output is fixed is defined. Then, Hotelling's lemma yields beef and veal output supply and variable input demand functions. Using the conditional shadow price functions, one can derive the equations for the optimal level of each of the quasi-fixed factors (i.e., grazing and forage area, suckler cow stock number and dairy cow stock number). It is assumed that quasi-fixed factors need more than one period to adjust to their optimal levels and that they adjust according to a partial adjustment mechanism. In a similar way, the conditional shadow price function for the rationed milk output yields the shadow milk supply equation. As the milk supply response depends on the quantities of quasi-fixed factors, it is possible to define different "levels" of supply response, from the short-term (no adjustment of quasi-fixed factors) to the long-term (all quasi-fixed factors adjusted to their optimal levels).

The functional form retained for the profit function to specify all these equations is the normalised quadratic function. Behavioural parameters involved in these equations are estimated econometrically. A mixed-estimation procedure was applied, which allows sample and non-sample information to be combined. The non-sample information consists of the usual (non-stochastic) theoretical constraints and other forms of prior information. Other prior information reflect prior ideas regarding specific model coefficients, based on previous research (input and output price elasticities for example), or agronomic characteristics (feed conversion characteristics, milk yields per cow for example). Unlike the theoretical restrictions, which are assumed to hold exactly, the prior parameter values are imposed in the form of stochastic relationships to reflect a priori uncertainty about the validity of these values.

Estimation was done separately for the 15 Member States of the EU. Data used for the estimation process are time series covering the period 1973-1995, taken from the SPEL database, and from the Official Journal of the European Communities as far as policy variables are concerned. The aggregate milk demand equation was not estimated but instead calibrated using an extraneous estimate of the demand elasticity. The shadow milk supply function cannot be estimated econometrically. The milk

output supply function is based on the expression for the shadow price of milk, which is derived by algebraic means from the profit function. Hence, this derivation gives those parameters of the milk supply function that describe the responsiveness of milk supply to changes in milk price, other prices and quasi-fixed factors. Therefore, only the "position" of the milk supply function was calibrated. This has been done using exogenous information about quota rents and structural features of the milk producing sector in each EU Member State. This exogenous information were both derived from the Eurostat FADN database and taken from existing studies.

Finally, the model of the EU's dairy and beef producing sector allows for analysing a wide range of policies targeting the milk sector: supply control (changes in the levels or removal of milk quotas); direct payment systems (payment per head for different types of animal, payment per ton of quota, payment per hectare); price support (for milk and for cereals through the adjustment of the price of feed).

### **1.7. A spatial equilibrium model of the EU's dairy industry (chapter 8)**

The model of the EU's dairy industry is a spatial equilibrium model of a vertical multi-market sector. Hence, the EU dairy sector is modelled as a vertical structure involving milk supply, milk processing into final dairy products and final demand for dairy products. The processing technology is modelled as a Leontieff allocation mechanism of milk components (milk fat and protein) among final dairy products. From this allocation mechanism, one can derive the raw milk derived demand function and the dairy product supply functions of the processing industry. The raw milk supply function and the dairy product final demand functions are specified as stylised functions relying on constant own-price elasticities.

Equilibrium is determined using the general framework of a competitive resource allocation problem involving various geographical regions and assuming transport costs for trading from one region to the other. Hence, the spatial structure of the model results from the assumption that trade across regions imply transport costs that differ according to the origin and the destination of trade flows. This competitive market equilibrium framework extends the interregional model proposed by Samuelson (1952) and Takayama and Judge (1971). Chavas et al. (1998) have shown that this extended version of the initial interregional model generates a competitive resource allocation equilibrium. Bouamra-Mechemache et al. (2001) show how this framework may be modified in order to incorporate the EU dairy policy so as to represent distorted competitive market equilibria under alternative policy scenarios.

Thus, the model of the EU's dairy industry is a comparative static model which, from the base year to the target year and conditionally to relevant policy instruments, solves instantaneously for regional shadow prices of implicit milk components, milk and dairy product prices, production, consumption and trade.

The empirical application of the model considers raw milk and 10 final dairy products: butter, skimmed milk powder, condensed milk, fluid milk, fresh products, casein, hard and semi-hard cheese, processed cheese and other cheese. The EU is divided into 9 regions: Belgium-Luxembourg, Denmark, France, Germany-Austria, Italy-Greece, Netherlands, Spain-Portugal, Sweden-Finland and United Kingdom-Ireland. An exogenous "Rest of the World" is also added in order to make world prices endogenous and be able to depict the EU trade policy instruments. The structure of the model allows to represent explicitly the main policy instruments currently in force in the CMO for milk and milk products: milk quotas, intervention prices (butter and skimmed milk powder), ceiling quantities for public intervention, consumption subsidies (butter and skimmed milk powder), production subsidies (casein), export refunds, import tariffs and quotas.

The model is calibrated on 1995 quantity and price data. All parameters and initial quota rents are derived from the existing literature.

### **1.8. A model of the EU's beef producing sector (chapter 9)**

The main objective of subtask 2.3 is to develop an EU sectoral model for beef in order to provide quantitative assessments of the impacts of reform proposals of the Common Market Organisation for beef and veal.

This subtask has been carried out by developing national supply models for the main EU beef producing Member States, and then using these models for simulating alternative policy scenarios.

A generic national analytical model has been developed first. The main feature of this generic framework is that it takes into account simultaneously the demographic structure and the biological relationships that drive bovine production, as well as the impacts of economic and policy variables on these dynamic demographic links.

Three subsets of inter-related biological and behavioural relationships are defined. The first one focuses on calves, the second one on female animals aged one year and over and the third one on male animals aged one year and over. In each subset, each animal in the herd at the beginning of a period may be either bred, slaughtered or exported during the period. Arbitration among alternative decisions applies to sub-categories of animals (such as heifers, suckler cows and dairy cows for female animals and bulls and steers for male animals) and generate for each sub-category various variable rates such

as the calf crop rate, replacement rates and slaughtering rates. Finally, based on the slaughtered quantities of each category of animals and the corresponding average slaughtering weights, the net production of beef and veal meat is determined.

Variable calf crop, replacement and slaughtering rates are key variables of the model since they reflect the dynamic links between all variables of interest. In the same way, average slaughtering weights are of key importance since they depict the linkage between the demographic adjustments of considered herds and meat supply. Therefore, a particular attention has been paid to the specification of these variables. Variable rates and average slaughtering weights are assumed to be dependent on economic and policy variables. However, as they must also enforce biological constraints, they are specified as logistic functions of explanatory variables. Such a specification allows for setting upper limits, fixed according to empirical observation and common knowledge, for the levels of the considered rates.

The main policy instruments currently in force in the CMO for beef and veal (i.e., intervention price and headage payments for the various categories of animals) are introduced as explanatory variables in variable rates and average slaughtering weight equations. Therefore, the model is able to capture the effects of changes in all these instruments on bovine production and beef and veal meat supply.

This generic analytical model has then been applied to 4 EU Member States: France, Germany, Italy and United Kingdom. These 4 Member States account for nearly two third of the EU 15 beef and veal production. All parameters of the national models (except biological upper limits) have been estimated using traditional econometric techniques applied to annual aggregate time series data covering the period 1973-1999. Data used were taken mainly from the Eurostat CRONOS database and from the Official Journal of the European Communities as far as policy variables are concerned.

### **1.9. A software for depicting the regional market of an Appellation of Origin (chapter 10)**

Subtask 2.4 is aimed at developing an EU sectoral model for wine in order to provide quantitative assessments of the impacts of reform proposals of the Common Market Organisation for wine.

Due to the great heterogeneity in vineyard specificity as well as in production and oenologic practices, that underlies the extensive differentiation of wines produced all over the EU 15, constructing a proper integrated sectoral model for the EU wine sector is a highly, if possible, difficult task.

On the other hand, one of the main feature of the new CMO for wine (implemented on the beginning of year 2000) lies in the shift from a price support policy to a quality support policy. This reorientation of support towards the improvement of vineyard and wine quality is associated with the strengthening of systems of supply regulation implemented at the regional level. Such a decentralised regulation increases the role of producers' unions and "interprofessions" in managing the structure of vineyards,

regulating yields and adjusting wine quality. Hence, the new orientation of the CMO for wine implicitly gives a prominent role to the system of Appellations of Origins, which is the most widespread example of a regional supply regulation system managed by an "interprofession".

The status of Appellations of Origins constitutes precisely an issue widely discussed within the WTO negotiations. Hence, the status of Appellations of Origins could be an important stumbling block between the WTO multilateral negotiations and the new orientation of the CMO for wine. Actually, the non-recognition of Appellations of Origins from the WTO point of view would seriously challenge the new orientation of the CMO for wine.

In that respect, it has been decided, instead of developing an EU sectoral model for wine in order to assess the impacts of changes in the CMO for wine, to focus the analysis of subtask 2.4 on the economics of Appellations of Origins. Our objective is to examine the welfare effects of the implementation of such a regional supply organisation, based on a barrier to entry for producers outside the appellation, allowing inside producers to regulate yields and to adjust wine quality. In doing so, we intend to contribute to justify on economic grounds the implementation of regional supply organisations such as Appellations of Origins.

For that purpose, the analysis starts with some theoretical work (Giraud-Héraud et al., 1998; Arnaud, Giraud-Héraud and Mathurin, 1999; Arnaud et al., 1999) aimed at developing a general analytical framework formalising the functioning of an Appellation of Origin. This first stage allows to show that this kind of supply organisation is similar to a problem of decentralised supply regulation. More specifically, the barrier to entry imposed to producers outside the appellation allows inside actors (i.e., the "interprofession") to behave as a "local monopoly" maximising its intertemporal profit. Then, by comparing the "local monopoly" situation to the perfectly competitive situation, it is possible to highlight the welfare effects of the implementation of such a decentralised supply regulation regime. Thus, it is shown that the possibility for the "local monopoly" to stock wine in order to achieve a given level of quality (i.e., to manage strategically a so-called qualitative reserve) decreases the total wine quantity supplied but improves the average quality of wine proposed to consumers, with respect to the perfectly competitive situation. This results in an increase in the market price of wine. These adjustments relative to the perfectly competitive situation are welfare increasing for producers and welfare decreasing or increasing for consumers, depending on the structure of their preferences with respect to wine quality. Consequently, the overall welfare effect may be positive or negative.

The second stage of the analysis of subtask 2.4 is directed at developing a regional software for empirically assessing the above described welfare effects of the implementation of an Appellation of Origin and, in doing so, emphasising the key parameters and assumptions as regards to the sign and magnitude of these effects. The main features of the proposed model are the following.

On the supply side, the uncertainty on quantity and quality of the yearly output supply, that characterises wine production, is taken into account. The "interprofession" disposes of a fixed vineyard area and of an upper-bounded stocking capacity. The stocking capacity is used as a qualitative reserve aimed at managing the quality of wine to be sold on the market. It is assumed that the "interprofession" knows perfectly the random distribution of yields and of the quality level. Each year, the "interprofession" has to decide the share of available supply to be kept in stock (and consequently the share to be sold on the market), provided the state (in terms of quantity and quality) of the qualitative reserve. This yearly arbitration is directed at maximising the expected intertemporal profit of the "interprofession".

On the demand side, a vertical product differentiation model, inspired from Musa and Rosen (1978), is adopted in order to take account of the heterogeneity in consumers' tastes. In addition, the potential competition exerted by wines produced outside the considered region is considered within the modelling of demand.

Thus, the software solves an optimal command problem where the series of the states of the qualitative reserve is a Markov process.

The empirical application of the software requires data (on the supply side and on the demand side) referring to a specific vineyard. Such data are extremely difficult to obtain. Hence, it has been decided to apply the software on two differentiated stylised vineyards: a Northern and a Southern vineyard. Data and parameters underlying these stylised vineyards have been calibrated on the basis of available empirical observation and common knowledge.

#### **1.10. Assessment of the impact of food quality and safety standards on EU-US trade in agricultural and food products (chapter 11)**

This part of task 3 is aimed at assessing the impact of current food quality and safety standards on EU-US trade in agricultural and food products. More specifically, we focus on the impact of US food quality and safety standards on EU agricultural and food exports to the US.

This part of task 3 has been carried out by first completing a thorough review of literature on technical measures. This literature review successively addresses the questions of the classification of technical measures, their effects on trade and the available methods for measuring these trade effects. Finally, existing studies that have attempted to measure the effects of technical measures in the context of trade in agricultural and food products are reviewed.

Relying on the literature review, it has been decided to retain the classification of technical measures proposed by Roberts et al (1999) in the remainder of the analysis, dedicated to the assessment of the impact of US standards on EU agricultural and food exports to the US.

The literature review suggests that there are four basic approaches commonly used to evaluate the trade impact of technical measures: frequency/inventory-based measures; price-comparison measures (or tariff equivalent estimates); compliance-cost measures; quantity-type measures. The impact of US standards on EU agricultural and food exports to the US has been assessed combining the first three approaches. In addition, an analysis of US detentions of EU agricultural and food exports has also been carried out.

Frequency/inventory based measures attempt to estimate the number of technical measures applied by a country, by type across product categories. These measures typically make use of inventories of non-tariff measures, including technical measures, which detail the number and type of measures by tariff line. This approach has been applied to the US and the EU in order to identify differences in both countries' food safety and quality standards. First, a detailed inventory database of food safety and quality standards in the US and the EU has been constructed. The database consists of 825 governmental regulations and standards laying down requirements (534 for the US and 291 for the EU) identified from an undertaken review of official publications (the Code of Federal Regulation in the case of the US and the Official Journal of the European Communities in the case of the EU). Based on this database, a comparison of the number and types of measures applied, as well as concerned categories of products, in both countries has been carried out. Secondly, the UNCTAD database on Trade Control Measures has been used in order to evaluate the frequency of technical measures by tariff line in the US and the EU.

Price-comparison measures attempt to quantify the price effect of technical measures. Technical measures alter relative prices between world and national markets. Hence, by comparing the domestic price of a product, which imports are subject to a technical measure, to some reference world price (inclusive of transport costs and any tariff applied by the considered country), provides some indication on the net effect of the technical measure. This price wedge is termed a tariff equivalent because under conditions of perfect competition, an ad-valorem tariff at the same rate would create the same wedge between the domestic and the reference world prices. A tariff-rate equivalent computed through this approach can thus be interpreted as the tariff rate that would restrict trade to the same level as the corresponding technical measure. The price-comparison method has been empirically implemented for some products exported by the EU to the US. A number of product case studies were undertaken. However, the majority of these were not successful, reflecting the inherent problems with the price wedge approach. A successful example was nevertheless obtained and is presented in this

report as an illustration. It concerns the estimation of the tariff-rate equivalent of hygiene requirements for poultry meat in the US. The case study refers to US imports from the EU and relates to high value poultry meat as typically exported by the EU to the US. The tariff-rate equivalent is obtained by comparing the US wholesale price for poultry meat to a calculated EU CIF export price to the US. Data used are quarterly time series covering the period 1996-2000 taken from USDA-ERS as far as the US wholesale price and the transport and insurance costs are concerned and from Eurostat for the EU wholesale price.

Compliance-cost measures attempt to estimate directly the additional costs that are imposed on an exporter for complying with the requirements induced by a technical measure applied by an importing country. Hence, the compliance-cost approach involves identification of the specific changes and procedures that businesses are required to undertake to comply with the considered technical measure. The process which suppliers follow in order to comply with technical requirements typically consists of two stages: adaptation of the production processes and/or the final product to facilitate compliance with the specified standard; production and supply of the product complying with the specified standard and compliance with conformity assessment procedures (Henson, 1997). Stage one is associated with non-recurring costs (i.e., one-off expenditure required to achieve initial compliance with the standard, such as investment in new capital for example) whilst stage two is associated with recurring costs (i.e., more permanent production and other supply costs required to supply the product that is in compliance and to demonstrate compliance has been achieved, such as product testing requirements for example).

The compliance-cost approach has been implemented in order to assess the problems and the associated costs for EU exporters to comply with the technical requirements for agricultural and food products in force in the US. For that purpose, a survey was undertaken of EU exporters of agricultural and food products. A questionnaire was defined involving three distinct parts. The first part aimed to identify the main characteristics of the exporting firm. The second part aimed to assess the importance of technical requirements relative to other factors influencing agricultural and food exports to the US. The third part aimed to assess the costs of compliance and associated problems incurred by EU firms to export to the US. In this third part, questions were asked separately about four main stages of the compliance process: prior approval of production facilities; product reformulation and/or change in production, packaging and labelling; impact on production costs; border procedures.

A sample of 1800 exporters of agricultural and food products were selected from across 6 Member States (namely, Belgium, France, Germany, Italy, Netherlands and United Kingdom). An equal number of exporters (i.e., 300) was selected from each Member State. The survey was undertaken during the period April to July 2000. A response rate of 18% was achieved.

Finally, an analysis of US detentions of EU agricultural and food exports has also been carried out. The objective of this last phase was to complement previous analysis in identifying those products for which problems are actually experienced by EU exporters due to US technical measures. The US Food and Drugs Administration (FDA) publishes data on border detention of products for which it is responsible. These data provide some indication of the problems experienced by EU exporters, both in terms of those product categories most subject to detention and the reason for detention. Hence, a database of US border detentions of EU agricultural and food exports observed from 1997 to 1999 was constructed on the basis of the FDA published data. Then, an analysis of US detentions according three criteria: concerned Member States, concerned product categories and reasons for detention was completed.

### **1.11. Non-tariff barriers and market failures: Risk and informational aspects (chapter 12)**

This part of task 3 focuses on the economics of non-tariff barriers. It aims at developing an analytical framework allowing to analyse the welfare effects of domestic food quality and safety regulations and to examine their ability to address market failures.

Indeed, the legitimacy of public intervention, and in particular of border protection, can be found in the alleviation of market failures. Regarding food quality and safety regulations targeted market failures most of the time pertain to imperfect information (this includes risk but also uncertainty of consumers about the quality of the product). Hence, integrating this consideration in the regular framework of normative economics appears as a necessary building block in the effort to classify non-tariff barriers (NTBs) according to the degree to which they actually address market failures and/or impede trade.

The methodology that was used for this part of task 3 relies on three fields of the economic theory literature. The first one is the literature in International Economics, which tackles the issue of non-tariff barriers (NTBs) albeit in specific ways, i.e., mainly as quantitative restrictions (quotas, voluntary export restrictions) and minimum quality standards. The second one is the literature in Industrial Organisation, which gives a central role to market failures resulting from imperfect competition and imperfect information. The third one is the literature in Public Economics and welfare analysis, which investigates the effectiveness of regulations in the sense that they should protect consumers and alleviate market failures while minimising overall welfare loss. Law was also used in the part of the work devoted to the analysis of the US system of food safety regulation.

The general idea that is supported in this part of task 3 is that the beneficial effects of trade liberalisation may be attenuated by spontaneous market inefficiencies. The logical consequence is that when it can be shown that a domestic regulation successfully addresses these market inefficiencies,

even though it might result in restricting trade flows, the international community should acknowledge that there is a form of legitimacy which should be reflected in trade agreements.

Hence, combining elements of the three above-mentioned fields of literature, several analytical frameworks were developed in order to, first, illustrate how trade liberalisation may result in spontaneous or increased market inefficiencies. There are numerous possible cases where trade liberalisation may induce market failures. Two of them, that are particularly relevant in the context of food quality and safety standards, were retained: the presence of sanitary and phytosanitary risk and imperfect information on the quality of products.

The first three developed models build on the literature on both trade in a context where consumers face imperfect information on the quality/safety of the product and on quality/safety revelation and quality/safety effort (Akerlof, 1970; Shapiro, 1983; Donnenfeld et al., 1985; Donnenfeld, 1986; Grossman and Shapiro, 1988; Falvey, 1989; Daughety and Reinganum, 1995 and 1997). All three models consider that production, consumption and trade take place over two periods and assume imperfect competition on the supply side. In all three models, two qualities of the single considered product are distinguished: a high quality (or safe product) and a low quality (or unsafe product). On the demand side, the first two models consider a single consumer who purchases either zero or one unit of the product and whose willingness to pay is zero for the low quality or unsafe product and positive for the high quality or safe product. The third model considers a group of consumers and adopts the usual vertical differentiation framework proposed by Musa and Rosen (1978).

The first developed model investigates the welfare impact of trade liberalisation between two countries experiencing different levels of sanitary risk and production cost, the consumers being unable to detect the origin of the product sold on the market. The second developed model relies on a similar framework but put special emphasis on the impact of trade liberalisation on the behaviour of sellers in terms of testing and signalling the quality of their product. In this case, both countries exhibit equal levels of sanitary risk and production cost, but differ in their ability to control product's safety. The third model explores the economic mechanisms affecting product safety when consumers face different information structures. Three cases are considered: the search good situation; the experience good situation (as defined by Nelson, 1970); the credence good situation (Darby and Karny, 1973).

The fourth developed model is specifically designed for addressing the EU-US hormone-treated beef dispute. It corresponds to a particular case of the previous third model considering only one period, assuming perfect competition on the supply side and where the considered product is a credence good. This fourth model is used for investigating the welfare effects of opening the domestic market (i.e., the EU market where hormone-free beef is perceived as of higher quality) to foreign products (i.e., US hormone-treated beef) that are perceived as lower quality goods.

In a second stage, these four theoretical models are used to explore the effectiveness of different types of public regulation aiming at increasing consumer protection and circumventing market failures. A particular attention is paid to labels.

The second part of the analysis further examines some issues related to labelling policies. Indeed, there are several ways to implement a label and this second stage of the analysis aims to further examine the effectiveness of various labelling strategies. More specifically, three main questions are addressed: when should a regulator promote public labelling and when should labelling be a mandatory or a voluntary programme? How should public labelling be financed? Under which conditions a label "does contain" is more effective than a label "does not contain"? Lessons are drawn from developed analytical frameworks similar to the ones of the third or fourth model previously described, but complemented in order to take into account various types of labels and the associated labelling costs.

The third part of the analysis proposes an assessment of the US sanitary and phytosanitary legislation, from the point of view of the WTO rules. A special emphasis is paid to the so-called Delaney clause.



## 2 - THE DATABASE ON TARIFFS, TARIFF-RATE QUOTAS (TRQs) AND TRADE

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### 2.1. Introduction

The objective of this part of the project was to develop a comprehensive database on tariffs and imports which would make it possible to monitor the effect of past Uruguay Round (UR) market access commitments as well as future proposals for trade liberalisation.

The purpose of the trade database was twofold. First, the aim was to provide the basic material to other sections of the project, in particular the one dealing with market protection indicators (chapter 3) and the one centred on the trade model (chapter 5). The construction of market protection indicators requires precise estimates of the tariff commitments decided upon in the Uruguay Round Agreement on Agriculture (URAA) as well as corresponding detailed data on imports. The world trade simulation model also relies on precise quantification of the trade barriers (i.e., UR tariff and tariff-rate quota commitments but also applied tariffs, which are often lower than bound tariffs) which requires aggregating the many tariff lines into an average tariff that represents the trade obstacle faced by exporters.

Second, the trade database in itself was believed to be useful to the Commission's policy makers during the current Millennium Round. Indeed, many aspects of WTO negotiations in the field of market access are very technical, and crucial aspects are most often "in the details". For example, the product classification that was used to define UR tariff commitments is of particular importance because the way tariffs are defined and reduced can lead countries to find a way around the spirit, and even the discipline of the agreement.<sup>2</sup> It is presently extremely difficult to assess how the various WTO countries have fulfilled their UR tariff commitments, since the WTO has not provided detailed figures on applied tariffs that matched the bound tariffs. The difficulty is that no comprehensive data is available on these issues, and that, unless challenged by a third country, a country that does not fulfil its commitments has no particular sanction to face.

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<sup>2</sup> Details and technical aspects of the tariff schedules have proved important in recent years. For example, imports of gluten flour into the United States in 1998 in spite of countervailing duties because of a loophole in the definition of products at the 8 digit level of the trade classification.

Because of these technical aspects, which will prove important during the Millennium Round, the trade database was constructed with the principle of matching all the relevant information to each country's official schedule on bound tariffs, as submitted to the WTO. This has resulted in a database organised on the basis of the 8-digit Harmonised System (HS) classification. This introduced difficulties for gathering the relevant information, since the list of commodities includes some 2800 items. It is however a sine qua non-condition for being able to assess how the various countries have fulfilled their WTO commitments. Hence, unlike most other efforts, such as those of Agriculture Canada, US Department of Agriculture, Food and Agriculture Organisation for example, which attempt to aggregate the official WTO tariff commitments, the emphasis was put on working at a very detailed level of the classification, so that no information would be lost.

This chapter is organised as follows. The content of the database on tariffs and trade is described first. Then the modalities adopted and the main sources used for constructing this database are presented. Thirdly, the dataset on tariff-rate quotas that was developed independently from the database on tariffs and trade is briefly described. Finally, a thorough assessment of the implementation of market access discipline of the Uruguay Round is provided. Some lessons for the Millennium Round are drawn in the concluding section.

## **2.2. The content of the database on tariffs and trade**

The database is organised on the basis of the 8-digit HS classification for chapters 01, 02, 03 to 24 (i.e., all food products with the exception of fisheries products) and for selected items of chapters 29, 31, 35, 38, 40, 41, 50, 51, 52 (i.e., non food agricultural products, such as skins for leather, etc). It matches, for each country, the following information for each year since 1995 (unless otherwise specified):

1. The schedules on base (1995) and bound (2000) tariffs.
2. Import values, in national currency.
3. Import quantities.
4. Import quantities in secondary units (i.e., pieces, heads, dozen, hectolitres, etc and not kilos).
5. Unit values of imports under the Most Favoured Nation (MFN) status.
6. Unit values of imports non MFN.
7. Applied tariffs MFN.
8. Average applied tariffs non MFN.

9. Tariff-rate quotas (TRQ) information

10. Fulfilment of TRQs (for the EU only)

11. Import elasticities (for 3 countries only: EU, US, Canada)

The database on tariffs and trade was constructed for a set of countries. While datasets were completed in a satisfactory way for the EU, the US and Canada, the datasets for other countries remained flawed because of problems in the correspondence between the various sources of information. It was thus decided to focus on the EU, the US and Canada, and to provide less sophisticated data for the other countries (namely, Australia, Brazil, Japan, Korea and Norway).

One may underline that the database on tariffs and trade developed under this project has been used as part of the contribution of the EU Commission to the co-operative Agricultural Market Access Database (AMAD) project. This co-operative effort, involving the EU Commission, the Organisation of Economic Co-operation and Development (OECD), the Economic Research Service (ERS) of the US Department of agriculture (USDA), the Food and Agriculture Organisation (FAO), the United Nations Conference on Trade and Development (UNCTAD) and Agriculture Canada, aims to put together data on agricultural tariffs, tariff-rate quotas and trade gathered by the various institutions. This effort has led to the constitution of a large database that is now available online ([www.amad.org](http://www.amad.org)).

### **2.3. Modalities adopted and sources used for constructing the database**

#### ***2.3.1. Modalities and conventions adopted***

Because the database is oriented towards a real-time use in trade negotiations, the UR schedules of official tariff commitments were the starting point. A major difficulty was found in the revision of the official classification used in the WTO negotiations. Under the URAA, countries' base and bound tariffs are notified on the basis of the 1992 version of the Harmonised System. Since then, the WTO has asked member countries to submit a revised version of their tariff commitments in the new HS-1996 classification. When the database was being constructed, these revised tariff commitments were not available for many countries.

In many countries, some tariffs are specified in values per kilo, liter, or head of animal, i.e., as "specific" tariffs. This is particularly the case in the EU, the US and Japan, but the problem does exist in many other countries. One cannot perform any aggregation, computation and economic analysis on the basis of such tariffs. Therefore, they were converted into ad-valorem equivalents. Such a conversion requires import price data, available at the same level of disaggregation, which is a major obstacle. For the present case, the following conversion rules were adopted:

- the average 1995-98 unit values of imports were used as import price data;
- when these import unit values were not available, they were approximated by corresponding export unit values;
- for those commodities that were not traded in any of the four years, the average unit value of imports of the most similar commodity was used as a proxy;
- for those tariff lines combining an ad-valorem and a specific tariff with a threshold mentioned (i.e., a minimum or a maximum tariff), for which either the ad-valorem component or the specific component is binding, the highest possible tariff was considered.

It is important to note that there is no solution that is fully satisfactory for converting specific tariffs into ad-valorem equivalents. One will always have to use a local approximation that is not necessarily robust to changes in tariffs. The AMAD group and the USDA have adopted different conventions from ours. Particularly, they convert HS-8-digit specific tariffs by using more aggregated price data. From our point of view, such a procedure introduces artificial tariff peaks in computed ad-valorem tariff equivalents (see Gibson et al, 2001).

### ***2.3.2. Sources used***

#### *2.3.2.1. The European Union*

For the EU 15, the UR schedule (WTO submission, HS96-8-digit), that covers 1764 tariff lines, determines the list of commodities included in the database. Practitioners call this list the "Geneva list".

Import quantities and values come from COMEXT. As the Eurostat COMEXT database is based on the NC-8-digit classification, this latter was matched manually to the HS96-8-digit classification. It is noteworthy that both classifications differ significantly and that this raised a lot of problems for matching tariff data to trade data. Note that the matching between the "Geneva list" and COMEXT resulted in non correspondence of the codes for roughly 15% of the tariff lines.

Data on applied tariffs come from various sources. In the EU, roughly 53% of imports (in value) are imported under preferential agreements, at a tariff that is most of the time much lower than the WTO (i.e., MFN) tariff. Tariffs under preferential agreements were extracted from the TARIC (NC-12-digit) database. Information on applied tariffs was also extracted from the UNCTAD's TRAINS database (at 8-digit level) and was checked against the applied tariffs published in the Official Journal of the European Communities. Although there were some discrepancies between the various sources, it was

possible to match the data with the 8-digit level data on import flows and to convert specific tariffs in ad-valorem equivalents.<sup>3</sup>

#### *2.3.2.2. The United States*

In the case of the United States, the UR schedule was also the starting point. The limitation here is that by the time the project was completed, the official schedule in the HS96 classification was still not notified to the WTO. Therefore, the starting point was the initial HS92 based schedule that showed some discrepancies with the HS96 data on trade flows.

Import quantities and values come from the US International Trade Commission (USITC).

Unlike the EU schedule, the US schedule includes in-quota tariffs. In order to make things comparable, a separate dataset was constructed for the US only with the Most Favoured Nation tariffs. That is, the US tariff dataset covers 1377 tariff lines.

#### *2.3.2.3. Canada and other countries*

For Canada, starting from the UR schedule, the other used data source is the Statistics Canada database on trade.

For other countries, the information gathered was more partial. Still starting from UR schedules, other data sources include the United Nation's COMTRADE and TRAINS database (both at the 6-digit level). However, the data were quite poor and in most cases the product codes of the trade data did not match the product codes of the tariff data, in spite of the so-called "harmonised" system.

### **2.4. The dataset on tariff-rate quotas**

Following a request from the Commission's representatives, highlighting the fact that tariff-rate quotas (TRQs) were an important issue in the WTO negotiations, an extensive dataset gathering together available information on TRQs was completed. This dataset covers the 35 countries that have notified tariff-rate quotas to the WTO. The main source was the WTO schedules and notifications that were obtained from the WTO Secretariat.

In the meantime, the AMAD group started an extensive collection of data on tariff-rate quotas. Hence, the dataset on tariff-rate quotas developed under this project was made available to the AMAD group and is now included in the AMAD database.

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<sup>3</sup> There is no import data available at a more detailed level because of confidentiality of information, since it would be possible to track the individual importer.

In addition, one may underline that, during the project's life, an assessment of the implementation of UR tariff-rate quotas in various countries has been carried out by the International Agricultural Trade Research Consortium. Following a request from the Commission's representatives, researchers involved in this section of the project provided the database for the study and wrote the EU section in the report (Bureau and Tangermann, 2000). This work allowed for feeding the dataset on tariff-rate quotas with information on fulfilment of TRQs for the EU.

## **2.5. A thorough assessment of the implementation of market access discipline of the Uruguay Round**

The database on tariffs and trade has made it possible to compare the structure of protection chosen by the EU to that retained by other WTO countries. Because the data spans from 1995 to 2000 (data on import flows span from 1994 to 1998 for most countries), it also gave the possibility for a thorough assessment of the implementation of market access discipline of the Uruguay Round.

### ***2.5.1. Technical arrangements made it possible to minimise the constraints that resulted from UR market access commitments***

As a first evaluation of the market access provisions of the URAA, various studies had pointed out that, in spite of the highly significant potential benefits in the long term, the impact during the 1995-2000 implementation period would be low (IATRC, 1994 and 1997; Josling, 1998; OECD, 1995; Tangermann, 1995 and 1996). It is commonly admitted that almost all WTO member countries have acted to minimise the constraints of market access commitments, using a combination of factors such as<sup>4</sup>:

- The over-estimation of the tariff equivalents at the time of the conversion of quantitative restrictions on imports into bound tariffs (this phenomenon denominated "dirty" tariffication has led to an unused protection identified as the "water" in the tariff).
- The presence of very high tariff peaks which completely prevent imports for certain products, in spite of average rates of protection relatively low when they are calculated on the whole of the agro-food products.
- The setting of very low thresholds to the special safeguard clause, which are used to grant supplements of protection in relatively normal market situations.

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<sup>4</sup> These factors are discussed in details in the FAIR5-CT97-3481 document: Véganzones, Bureau and Hofstetter (1999).

- The lack of transparency of some tariff structures, which allows statistical manipulations that make it possible to dissimulate the failure to decrease particular tariffs or to reallocate particular products under more protected headings, with the favour of a change in the nomenclatures.
- The strategic repartition of tariff reductions between tariff headings, so as to reduce as little as possible the protection on sensitive products, and to achieve the average reduction objective by large tariff cuts on products of marginal importance or initially very little protected (this phenomenon is called the "dilution" of tariff reductions).
- Questionable methods of calculation of the level of the tariff-rate quotas.
- The restriction of access to tariff-rate quotas sometimes to a predetermined list of countries, in spite of the spirit of the Agreement which supposes an allocation according to the clause of the most favoured nation.
- Restrictive methods for allocating import licenses that result in underutilised quotas, which therefore show low fill rates.

These provisions legally do not constitute violations of the Agreement insofar as they in general respect the commitments entered into in the official Lists (which have legal value), even when those did not correspond to what was envisaged by the Modalities. Thus, even with a careful examination of the schedules of the various countries, the researchers involved in this section of the project did not observe infringements at the rules of the WTO.

Many points were however raised which show that countries used significant degrees of freedom when complying to the rules initially laid down in the WTO Modalities. One can quote:

- The compatibility of the allocation of tariff-rate quotas under minimum access with preferential agreements such as NAFTA. As an example, preferential duties under NAFTA seem lower than the corresponding in-quota tariffs in Canada. This could result in making it easier to import from the United States than from other countries, which should normally access the Canadian market under the minimal access provisions.
- The maintenance of tariff peaks which keep isolating the Canadian dairy sector and turn tariff-rate quotas into simple quantitative restrictions (normally eliminated during the Uruguay Round).
- Pigmeat imports regulations in Japan, which de facto maintain a variable levy.
- Taxes levied by the Japanese state import monopolies, which add to tariffs and result in a lack of transparency (more generally, the complexity of the whole of commitments makes it extremely difficult to perform a decent evaluation of the implementation of the Uruguay Round provisions).

- Minimal reductions in tariffs for processed products (initially more protected) in Australia, which suggest that there is a significant amount of tariff escalation.
- Implementation of tariff schemes at an excessively detailed level of the statistical classification (up to 11 digit) in Korea that makes it possible to minimise the scope of the Uruguay Round commitments.
- The persistence of non tariffed commodities in Israel that makes an exception to the general rules of the WTO.

Without being challengeable under the WTO (since the schedules are the legally binding commitments), these provisions are questionable and appear to be in opposition with the spirit of the initial rules of the WTO.

Hence, the assessment of the implementation of the URAA that was made here using the database on tariffs and trade and the dataset on TRQs sheds a different light on the compliance to the spirit of the Agreement across countries. From the point of view of the setting of the tariff-rate quotas, of the management and allocation of import licenses, of the transparency of the notifications to the WTO, the European Union has a better record than most countries of the sample. The European Union is one of the few countries, with Morocco and Argentina, which has not used (or very little) a strategic allocation of tariff reductions across the tariff lines covered by the Agreement. In most countries, one observes large cuts in those tariffs set on products of minor importance in terms of consumption. This made it possible to achieve the 36% average goal of reduction with limited reductions of tariffs set on most sensitive products.

The database on tariffs and trade shows no visible increase in flows of imports over the period of implementation of the URAA that seems to have resulted from the Agreement. The fact is that it was possible to work only on a very limited number of years corresponding to a period where the implementation of the Agreement was not completed (the most recent statistics that were used were for the year 1998). It seems, however, that the average 36% decrease in tariffs was a not very active binding during most of the 1995-2000 period. In most countries, the main result of the Agreement in terms of market access was the minimal 15% cut in tariff that was implemented on the bulk of products in large demand.

The improvements of the access to agricultural and food markets, which took place, are undoubtedly more due to the tariff-rate quotas than to the decrease in bound tariffs. It is noteworthy, for example, that observed growth of some import flows takes place under tariff-rate quotas that resulted from minimal access provisions (milk and margarine in Canada; dairy products and rice in Japan; cheeses and other dairy products as well as chocolate in the United States). Nevertheless, the European Union is seldom in the situation of being a serious competitor of exporters like the Cairns group or the United

States in supplying of these quotas. The reasons are multiple: in certain cases that is due to the lack of competitiveness of the European products (corn, butter); in other cases to the geographical proximity between the import and the export markets (Asian markets are closer to the United States or Australia); in other cases, this is caused by the existence of preferential agreements, NAFTA in particular, or the ability of the US administration to obtain a preferential treatment from state trading enterprises (in Japan, Korea or Israel).

### ***2.5.2. Implementation and management of TRQs***

A particular attention was paid to the way the EU has opened tariff-rate quotas after the Uruguay Round.<sup>5</sup> The URAA minimum access commitments were made through the use of tariff-rate import quotas, with a lower tariff (in-quota tariff) for imports within the quota, and a higher tariff rate (out-of-quota tariff) for imports exceeding the quota. A total of 35 countries including all OECD member countries (except Turkey) have scheduled 1370 tariff-rate quotas.

TRQs were put in place to deal with the fact that tariffication of existing quantitative restrictions would have shut off all trade in many cases. All countries were expected to allow access to their domestic markets for imports equivalent to at least 3 percent of domestic consumption in the 1986-1988 base period. This proportion was to rise to 5 percent by the year 2000 (developed countries). These provisions refer to "minimum access". When traditional imports did not represent a sufficient percentage of domestic consumption, TRQs were applied so as to meet URAA minimum access commitments. In addition, the URAA agreed that pre-existing market access had to be preserved. That is, access conditions for historically established import quantities would be maintained by a provision referred to as "current access". Hence, for a number of products, countries opened up TRQs in order to meet the obligations of current access.

No specific provisions were approved in the URAA regarding the administration of TRQs, although relevant WTO rules were to apply. In practice, the complexity of the tariff structure in the presence of TRQs results in a certain lack of transparency. In the tariff schedules, it is often difficult to identify the duties that particular imports will face, given that there are two tariffs, a quota and several specific situations like over-quota imports, quota under-fill and preferential quotas and tariffs. TRQs were defined so as to respect current access, or to ensure minimum access to the domestic market for imports. In practice, TRQs under current access can be restricted to traditional importers. TRQs under minimum access should be opened to would be exporters on the MFN basis. However most countries have not notified which quota is under which regime.

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<sup>5</sup> This paragraph builds on the document prepared for the IATRC report on tariff-rate quotas: Bureau and Tangermann (2000).

In terms of administering TRQs, WTO member countries use a host of different methods. Countries have basically two ways of allocating their TRQs: the first one is global, the second one is country-specific. Global allocation applies on imports regardless of country of origin, all countries being free to compete. Under the country-specific allocation, the importing country grants one part of the TRQ to an exporting country. In this case, WTO rules require that all substantial suppliers (defined as countries with a market share of over 10 percent, see par. 7 of Article XXVIII:1) have to receive a share. Licenses are often used as a means of administering TRQs, and can be assigned to importing or exporting firms (or to both such that an importing firm needs to present both an import and an export license to import authorities). Allocation can follow different forms, from "first-come first served" and licenses on demand to auctioning, lottery, etc. These different methods of administering TRQs may lead to different inefficiencies and inequities. In addition, other conditions placed on TRQ administration like quota limits per firm also have the potential to generate inefficiencies.

In most countries, TRQs have mainly been used to maintain traditional import flows but have not led to a large increase in trade. This can be explained by several factors:

- URAA commitments were based on the Modalities established by the WTO, which were not incorporated as part of the URAA. What countries actually agreed upon was what they respectively submitted in their schedules, whether or not it reflected the application of the Modalities. As a result, the Modalities discipline was not always followed in practice, and the operation of TRQs was left to individual countries' discretion. For example, some countries calculated their TRQs in a way that do not always correspond to 3 percent of domestic consumption. This also made it possible to minimise market access increases for more politically sensitive commodities.
- TRQs were often set for products characterised by tariff peaks, so the out-of-quota tariffs remain prohibitive.
- Commitments as well as management of TRQs lack transparency in many countries. This creates grey areas that allow some countries to get around some of the URAA disciplines. One example is the latitude given to (or taken by) countries either to use different (and sometimes inconsistent) statistical classifications or to define products at a level of very fine detail, restricting access to quotas for particular products from specific origins.
- TRQs under minimum access are not always allocated on a Most Favoured Nation (MFN) basis as was specified in the Modalities. Countries have used existing freedom to fill not only current access but also, sometimes, minimum access TRQs with imports under preferential agreements. In such cases, one or a few countries are allowed access to the TRQ concerned and can take advantage of the new trade opportunities. Where this is the case, it considerably limits the scope of the current functioning of the URAA in terms of trade liberalisation. In some cases, quotas are allocated to

countries that are unlikely to be able to export the relevant commodity. In other cases, tariffs under preferential agreements are lower than the in-quota MFN tariffs so those minimum access quotas are, *de facto*, filled with preferential imports from particular countries.

- Even though countries are obligated to open their markets to imports at particular tariffs within the TRQs specified in their schedules, they are not required to import quantities corresponding to the TRQs. Market conditions may preclude a 100 percent quota fill rate. In some cases, only a small share of the TRQ quantities is actually imported because of the manner in which TRQs are administered. This translates into a low fill rate for such quotas.

The EU created a large number (87) of TRQs after the Uruguay Round. Unlike those of nearly all other countries, quotas in the EU's schedule are clearly categorised as minimum access or current access TRQs, providing transparency in this regard. Roughly two-fifths of the EU's TRQs come under current access. They usually provide continued access, on a bilateral basis, for exporters who in the past enjoyed preferential access to the EU or who had low or zero tariff access to EU markets for products under voluntary restraint agreements. As far as quantities are concerned, the EU's current access quotas tend to be much larger than those created under minimum access.

In establishing the TRQs, it appears that the EU has generally not deviated from fundamental rules in the Modalities. As in many other countries, there was a bit of "dirty quotification" in the EU, both in terms of product specification and calculation of minimum access quantities based on domestic consumption.

In the EU, the relationship between in-quota tariffs and out-of-quota tariffs differs greatly between current and minimum access. Under current access, in-quota tariffs as percentages of above-quota tariffs vary widely across products, because the individual TRQs reflect their historical origins and, hence, the (usually) low levels of protection that the EU had historically agreed upon with the exporting countries concerned. For most minimum access TRQs, on the other hand, the EU has set in-quota tariffs at a universal percentage (32 percent) of out-of-quota tariffs, and has not distinguished between less and more sensitive products. For both current and minimum access quotas, in-quota tariffs remained constant during the URAA implementation period, so that over time they have risen relative to the declining out-of-quota tariffs.

In administering license allocation under the TRQs, the EU has not been particularly inventive, either in using approaches that make it difficult to import the products concerned or in devising innovative approaches or methods, such as auctioning, that are economically more convincing than the other, more frequently used, approaches.

Fill rates for TRQs in the EU have been reasonably high and have increased over time. It is interesting to note that some of the larger current access quotas have exhibited relatively low fill rates, more so than have minimum access quotas. This was particularly so with current access quotas for feedstuffs that in the past was used as cereal substitutes in the EU. With the significant cut in EU cereal support prices, it is no surprise that import demand for these feedstuffs has declined noticeably. As far as we can see, no case has been identified in which the EU has deliberately used quota management procedures to make access to its markets more cumbersome than expected under a TRQ regime.

Overall, it appears that the EU has played a reasonably fair game as far as TRQs are concerned. Concerns do remain, though, as to the exact articulation of the Europe Agreement and the quotas under minimum access. The EU has indicated in its schedule that imports under the (preferential) Europe Agreement could be counted against certain quotas. Even though this provision is used when preferential tariffs under the Europe Agreement and in-quota (MFN) tariffs are similar, other countries fear that this could result in Central and Eastern European countries taking greater advantage of the EU increase in market access under the minimum access provisions.

## **2.6. Conclusion: Lessons for the Millenium Round**

Even if there is not or few infringements to the rules of the WTO as far as market access provisions of the URAA are concerned, lessons for the Millenium Round can be drawn from the many deviations to the spirit of the Agreement which were observed. The European Union over-estimated the tariff equivalents during the "tariffication process" and set relatively lenient thresholds for the triggering of the safeguard clause. However, the EU did not use much the various mechanisms making it possible to minimise the scope of the Agreement, compared to its trading partners. In the next round, it is likely that it would be in the interest of the European Union to:

- Base future commitments on a further reduction of tariffs and an increase in minimal access using the Uruguay Round benchmarks, rather than defining new reference values and periods. Because of the changes in the EU consumption of grains experienced since 1995, and because of the fall in the cereal intervention price, the definition of new commitments on minimal access would result in large grain imports.
- Tighten the constraints so that tariffs be reduced in a more uniform way. This would make it possible to avoid the strategic allocation of the bulk of higher reductions towards the least sensitive products. Indeed, in the Uruguay Round, these degrees of freedom were used in a larger extent by other countries than the European Union.
- Promote reduction in tariff peaks. This would create difficulties in some sectors such as the beef and veal, and would require a reform of the corresponding Common Market Organisations. Nevertheless,

it looks like the only way to open third countries' markets to European products such as wines and spirits, which still face prohibitive tariffs, in particular on Asian markets.

- Press for more transparency in the schedules and in the tariff reduction procedure, to make sure that the possibilities of manipulating classifications and statistical series will be limited. This could bring the EU representatives to defend the idea that WTO commitments on tariffs should be specified at the 6-digit level of the United Nations Harmonised System of classification (the only level for which there is a true international harmonisation. Beyond the 6-digit level, the codes are no longer harmonised across countries). The countries which least opened their market are those which could exploit the flexibility of engagements with 8, 9 or 10 digits.

- Strengthen the disciplines on the methods of management of tariff-rate quotas. There too, restrictive procedures were used by other countries in a larger extent than in the EU. The European Union could gain in particular with the prohibition of the management of these quotas by public monopolies, sensitive to political interference and discretionary import authorisations.

With regard to the strategic interest for Europe "to push" for a decrease in tariffs or, on the contrary, to an increase in tariff-rate quotas, it is quite difficult to answer. Large decreases in tariffs in the EU would require a substantial reform of some Common Market Organisations where producers are still well insulated from world prices. An increase in the level of current tariff-rate quotas would lead to limited benefits for European exporters. These quotas seldom relate to products where Europe has a real comparative advantage. In the future, the European Union could even less benefit from these quotas because of the foreseeable end of export refunds. Moreover, an increase in the level of tariff-rate quotas would not mean necessarily more opened markets, insofar as third countries seldom fill their quotas at 100%. Nevertheless, the most promising markets for the European exporters (Asia) remain protected by extremely high customs duties. It is not likely that a cut in these tariffs, that would necessarily remain limited, would allow a significant improvement in the access to these markets, unless measures of crest lowering of the tariff peaks are taken. The extension of tariff-rate quotas undoubtedly remains the only realistic prospect to penetrate these short-term markets. It will then be necessary to give a very detailed attention to the mode of calculation of these quotas, and to the related methods of management so that TRQs are actually opened with the some products on which Europe can be competitive. Statistical methods of calculation of minimum access should ensure the opening of quotas on processed products, on which the European Union seems to have a capacity of stronger export. It is indeed on these products that one observes significant progressions of European exports since 1994.



### **3 - MARKET ACCESS INDICATORS**

#### **Assessment and comparison of tariff structures chosen by the European Union and the United States under the Uruguay Round Agreement on Agriculture**

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#### **3.1. Introduction**

The general objective of this part of the project was to construct indicators of trade restriction and, on the basis of these indicators, to assess and compare the improvement in market access that was permitted in the UE and other countries by the URAA.

The proposed analysis focuses on tariff commitments under the URAA and on the EU and the US. It aims at measuring how much liberalisation UR tariff commitments allowed to achieve in both the EU and the US by the end of the implementation period, compared to the initial situation.

The analysis retains the TRI (Trade Restrictiveness Index) and the MTRI (Mercantilistic Trade Restrictiveness Index), proposed by Anderson and Neary (1994 and 1999), as indicators of trade restriction. Both indicators are empirically implemented for the EU and the US. The empirical analysis involves three stages. Firstly, the rates of change of the EU and US TRI and the MTRI between 1995 and 2000 are computed using the base and bound tariffs of both countries as submitted under the URAA. This first stage allows for assessing and comparing the extent of the improvement in market access that was permitted in both countries by the URAA. Secondly, the rates of change of the EU and the US TRI and MTRI are computed using two alternative schemes of tariff reduction: the "Swiss formula" and the uniform tariff reduction. This second stage allows for assessing and comparing the impact of the uneven allocation of tariff cuts across commodities implemented by the EU and the US under the URAA. Thirdly, the levels of the EU and the US MTRI are computed for the years 1995 and 2000. This third stage adds information on the EU and the US tariff structures at the beginning and at the end of the URAA implementation period.

This chapter is organised as follows. In section 2, the various families of measures of trade restrictiveness are reviewed, emphasising the pros and cons of the different existing types of measures. Section 3 is dedicated to the empirical implementation of the TRI and the MTRI. In section 4 results

obtained for each of the previously described three stages of the empirical analysis are successively presented and discussed. Section 5 concludes and draws some policy recommendations.

### **3.2. Available measures of trade restrictiveness: A review**

First of all, let's specify that to narrow the discussion, only production and consumption distortions are considered in our review. That is, we exclude the possibility of gains or losses due to changes in the terms of trade or in the scale of firms emphasised by the recent theories of imperfect competition and trade (see, Krugman, 1979). Secondly, policy instruments that are referred in the course of the analysis are principally import barriers, in particular tariffs.

One may distinguish two main families of measures of trade restrictiveness: incidence measures and outcome-based measures (Pritchett, 1996). In order to understand the crucial difference between the two approaches is important to keep in mind two points. Firstly, the two questions "how much protection is given" and "how much distortion is induced as a result" are distinct. Secondly, the effects of trade policy are the result of the interaction between the level of protection and the structural features of the economy.

#### **3.2.1. Incidence measures**

Incidence measures are based on the direct observation of the policy instruments. They provide an *ex ante* measure, since they ignore any second-round effects of the policies on the market (economy) under examination. In a sense, they attempt to measure the level of protection without considering the rate at which the level of protection is translated into market (economy) specific trade distortions. The level (or dispersion) of tariffs and the frequency of the various types of non-tariff barriers (NTBs) are typical examples of incidence measures.

Apparently, the mere count of NTBs, such as in Olechowski (1987), can be considered only suggestive of the severity of the distortions and is unreliable for cross-country and intertemporal comparisons of the level of protection. The height of tariffs, on the other hand, is less prone to subjective evaluations than the "counting" of NTBs. Nevertheless, as we will see, even in this case it is difficult to define an unambiguous aggregation procedure.

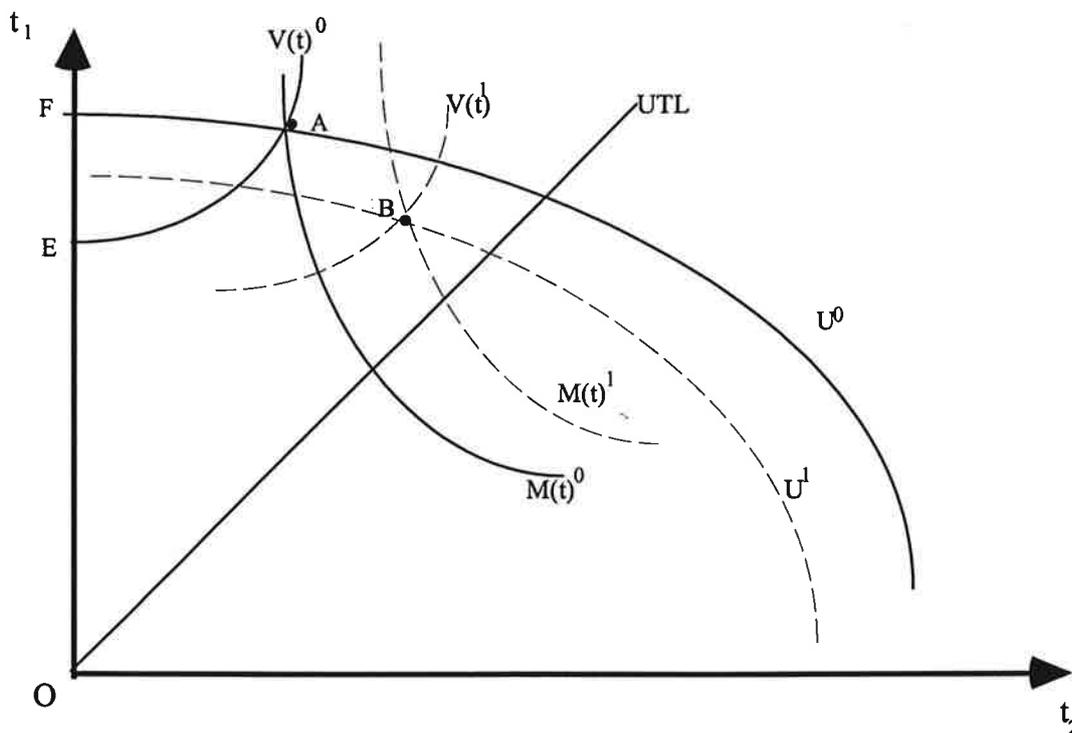
The distinction between the two metrics mentioned above – protection and distortion–, as a matter of fact, would not matter if they gave the same results, that is if the restrictiveness of trade policy could unambiguously be measured by the height of the tariff. When tariffs apply to more than one good, there is something intuitive about the idea that the effects of protection must be related to the mean of the tariff schedule. For example, the URAA requires each member country to reduce the simple average tariff by 36%.

However, it is clear that the same (average) height of the tariff can have very different impacts according to the number of imported goods it is applied to. The easiest solution, and the one often adopted in practice, is to aggregate tariffs by weighting them by the imports (valued at border prices) of each good. This approach immediately runs into difficulties if there is a positive correlation between import demand elasticities and tariff levels. If this is the case, high tariffs receive a low weight whereas low tariffs receive a high weight.

Another measure of trade restrictiveness is the coefficient of variation of tariffs. This is based on the intuition that a greater dispersion of the tariff structure implies larger distortions. For reasonable parameter values, however, it can be shown that this is no more satisfactory measure than the trade-weighted average tariff (Anderson, 1995). More generally, all purely statistical measures (i.e., tariff moments) have serious drawbacks on a theoretical ground.

A diagram (Figure 3.1) can be used to provide a graphical illustration of the possible inconsistencies arising from tariff moment measures. Following Neary (1995), let us assume that in a small open economy there are 3 goods: good 0, the untaxed numeraire, and goods 1 and 2, which are net substitutes and traded subject to ad-valorem tariffs (respectively,  $t_1$  and  $t_2$ ).

**Figure 3.1. Inconsistent measures of a tariff reform**



If we assume that for each value of  $t_1$  and  $t_2$  there is a unique second best optimal value of the other tariff, we can draw the iso-welfare contour  $U$ . The iso-welfare loci ( $U^0, U^1$ ) have always a negative

slope, so that second best "perverse" results are excluded. Welfare increases moving towards the origin.

The curves labelled  $M(t)$  illustrate the loci of tariff factors along which the import-weighted average remains constant. Their shape depends on the substitution properties of the economy, and they are necessarily downward sloping in this case.

$V(t)$  are iso-variance contours. Since the partial derivative of the variance with respect to tariff factor  $i$  is equal to:

$$dV(t)/dt_i = 2(t_i - M(t))/n \quad (1)$$

the contour's slope is equal to

$$dt_1/dt_2 = -(t_2 - M(t))/(t_1 - M(t)) \quad (2)$$

In this case the partial derivatives must have opposite signs, hence the slope is positive. The variance increases with distance from the uniform tariff locus (UTL).

The index 0 and 1 indicates the effects of a tariff reform from A to B. Points A and B lie on two different iso-welfare contours and the reform is welfare-increasing, since  $U^1 > U^0$ . If we used the mean tariff index, we would register a rise in protection, since point B is on an higher locus ( $M(t)^1 > M(t)^0$ ). On the other hand, the coefficient of variation would show a reduction of dispersion (lower variance –  $V(t)^1 < V(t)^0$ , higher mean). However, it should be noticed that area AFE represents a set of (possible) tariff reforms, which are welfare improving, but lead to higher coefficient of variations (lower mean, higher variance).

### 3.2.2. Outcome-based measures

Outcome-based measures assess the deviation of the actual outcome from what the outcome would have been without the trade barriers. These instruments provide an *ex post* measure, since they take into account (at least some of) the effects of trade policies. This means that the economic effects provide the weights used in the process of aggregation across markets or across policy instruments. One commonly distinguishes two types of outcome-based measures: those based on trade intensity and those based on the equivalence among trade barriers.

#### 3.2.2.1. Trade intensity measures

Trade intensity measures are based on a structural model of trade, and then investigate how trade barriers affect trade flows. The basic measure of openness is the trade intensity ratio: exports plus imports divided by GNP (Leamer, 1988).

In order to attribute to trade barriers any differences among countries in the level and pattern of trade, it is necessary to control for differences in terms of resources, tastes and natural barriers. Leamer (1988), for example, specified an Heckscher-Ohlin-Vanek model of trade flows, and used the differences between the predicted and the actual trade intensity ratios as an indicator of the level of openness.

The measures developed within this approach differ according to the set of variables, the functional form and the model chosen in constructing the counterfactual of what would have happened under an alternative policy (for example, free trade). As it can be expected, the results obtained are very sensitive to the choices made for the estimation of the trade equations.

With this approach, trade data are used as circumstantial evidence of barriers. This means that data on trade barriers do not appear explicitly, and the restrictiveness is evaluated by the residuals in the estimated trade equations. Since the interpretation of the statistical and economic significance of these residuals is not obvious (Harrigan, 1991; Feenstra, 1995), a better approach might be to include measures of tariff and non-tariff barriers in the equation, and to measure their restrictiveness in terms of their contribution to the determination of trade. However, there is a simultaneity problem, since high tariffs are often introduced in those industries with high imports. There are examples of studies that explicitly recognise the endogeneity of tariffs and non-tariff barriers, modelling these within a political economy framework (Trefler, 1993). Nonetheless, the data problems and the model construction difficulties remain formidable.

#### *3.2.2.2. Measures based on the equivalence among trade barriers*

The starting point for this second type of outcome measures is the acknowledgement that the idea of a "trade distortion" cannot be considered a simple, undifferentiated concept. It includes different elements that can be captured by different indicators. As a matter of fact, there is a long tradition in the analysis of border policies to convert various protectionist instruments and particularly non-tariff barriers into tariff equivalents. For example, the equivalence between tariffs and import quotas has attracted a large body of research which shows that "full equivalence" (that is, equivalence in terms of all relevant economic effects) is almost never valid, since it requires very stringent assumptions (Bhagwati, 1965).

Although there is not a conceptual framework where all possible impacts are taken into account, it is possible and indeed useful to construct consistent measures defined in terms of a single type of effect. As soon as we think about the problem of finding a single number capable of summarising a set of policies applied in different markets, it is necessary to specify the type of information we want to summarise. This means that in the process of aggregation we want certain basic information

maintained or, put in a different way, that the final single number is equivalent to the original multiple data in terms of the information we are interested in.

According to Anderson and Neary (1996), a general definition of a policy index is as follows: depending on a pre-determined reference concept, any aggregate measure is a function mapping from a vector of independent variables - defined according to the policy coverage - into a scalar aggregate. Consequently, the elements that define a theoretically consistent policy index of trade restrictiveness include the following:

- the policy coverage (e.g., tariffs, import quotas, border and domestic policies, etc);
- the reference point for the "equivalent-impact" we are interested in (e.g., iso-welfare measures, iso-income measures, etc);
- the scalar aggregate, that is the policy instrument into which are translated the policy measures covered (e.g., tariff equivalent measures, subsidy equivalent measures, quota equivalent measures, etc).

The greatest advantage of this class of measures is that they are theoretically consistent, since the equivalence among policy instruments is determined according to a fundamental economic structure. Secondly, it can be pointed out that they are unequivocal, because their definition is predetermined.

Compare these fixed definition indicators with the incidence measures. Such measures are defined by the formulas or techniques embodied in their generation, but the interpretation is questionable and it is not easy to say exactly what information is conveyed. The notion of a theoretically consistent indicator is to prevent any problems of interpretation, although there could be many problems in terms of practical implementation. Consequently, this approach changes the terms of the professional debate. The discussion is over the practical feasibility or how best to calculate the indicator, whereas the interpretation and the properties of the indicator are predetermined by its definition (Josling, 1990).

Finally, in terms of use of indicators in trade negotiations, we have already seen that commitments under the GATT were traditionally expressed in terms of a simple incidence measure like the average tariff. A major obstacle to the political use of outcome measures in place of incidence measures is that while the latter reflect only a change in policy, the former reflect both a change in policy and a change in exogenous market conditions (e.g., world prices, exchange rates, structural parameters, etc). Thus, governments are reluctant to commit themselves to attaining or maintaining a negotiated level of an indicator that is only partly under each country's control. Nonetheless, theoretically sound measures can be very useful in order to assess the impact of different types of commitments and to evaluate the implications resulting from the choice of alternative tariff reduction formulas.

In this part of the project we retained outcome-based measures as indicators of trade restriction because these are theoretically consistent measures. More specifically, we retained two different types of measures based on the equivalence among trade barriers: the TRI (Trade Restrictiveness index, i.e., the uniform tariff equivalent in terms of welfare, Anderson and Neary, 1994) and the MTRI (Mercantilistic Trade Restrictiveness Index, i.e., the uniform tariff equivalent in terms of imports, Anderson and Neary, 1999).

### 3.2.3. The TRI and the MTRI

#### 3.2.3.1. The TRI

Let the index  $i$  denote goods  $i = (1, \dots, N)$  that are sold at the international price vector  $p^* = (p_1^*, \dots, p_N^*)$  and at the domestic price vector  $p = (p_1, \dots, p_N)$ . The vector  $z$  includes all the variables assumed exogenous, such as the world prices ("small country assumption") or the fixed endowment of factors of production. It should be noticed that assuming –like we do in the following– a small economy with perfect competition and constant returns to scale does not allow for terms of trade gains due to the trade policies. In other terms, we focus on the deadweight loss from distorting production and consumption decisions, ignoring possible gains from improving the terms of trade, or from shifting profits between countries due to changes in the scale of firms (Feenstra, 1995).

A representative agent represents the trade behaviour of the economy. Distributive issues are ignored and protective purposes are set exogenously by the government, which returns its net revenues from trade policy to the agent. It makes no essential difference whether imports are for final consumption or intermediate input use, nor does it matter whether export as well as import trade policies are considered.

The optimal behaviour of the representative agent can be expressed through the trade expenditure function,  $E(p, U, z)$ , and is obtained as the difference between the consumer's expenditure function,  $e(p, U)$ , and the gross domestic product function,  $R(p, z)$ . Making use of the properties of duality, we know that:

- the derivatives of the consumer's expenditure function with respect to prices equal the levels of consumption;

- the derivatives of the gross domestic product function with respect to prices are the economy's general equilibrium net supply functions<sup>6</sup>;
- the trade expenditure function is homogeneous of degree one in prices and its derivatives with respect to prices are the compensated import demand functions,  $I_i(p, U, z)$ , which are homogeneous of degree zero in prices.

Given this structure of supply and demand, the other element of the model is provided by the external budget constraint. The constraint is expressed through the balance of trade function,  $B(p, U, z)$ , that summarises the three possible sources of funds for procuring imports: earnings from exports, earnings from the distortion of trade,  $G$ , and international transfers. Assuming that the latter are equal to zero and that tariffs (vector  $t$ ) are the only trade policies, we get:

$$B(\cdot) = G - E(\cdot) = 0 \quad (3)$$

Total differentiating the external budget constraint (3) using the small country assumption ( $dp = dt$ ) implies:

$$B_U dU + B_p d_p = 0 \quad (4)$$

The first term ( $B_U dU$ ) is the change in net trade expenditures at constant prices that could take place, for example, as a consequence of a gift from abroad. The second term ( $B_p d_p$ ) is the marginal cost of tariffs, which is positive if tariff increases are inefficient. This is quite an intuitive assumption, but it should not be taken for granted, even if we have ruled out possible gains due to imperfect competition or due to terms of trade changes. In case of partial liberalisation, as a matter of fact, cross price effects can make the marginal cost negative.

The TRI is a uniform tariff equivalent, iso-welfare measure. In terms of policy coverage, for the sake of simplicity, the following presentation deals only with tariffs. Although the inclusion of import quotas introduces some analytical complications (for example in terms of how the quota rent is shared between the importing and exporting country, Anderson and Neary, 1992), both price and quantity import restrictive policies can be included in the TRI, as well as domestic policies (Anderson, Bannister and Neary, 1995).

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<sup>6</sup> Accordingly, each derivative can be equal either to the supply function or to minus the input derived demand function if the good is an intermediate input. Treating imports and domestically produced goods as imperfect substitutes (i.e., the "Armington assumption") and considering only final consumption, the derivatives of the gross product function with respect to prices of tariff constrained goods would be equal to zero.

The TRI (denoted  $\Delta$ ) is defined as the uniform scaling factor (or uniform price deflator) that, when applied to period 1 prices, permits the representative consumer to attain his initial level of utility  $u^0$  while holding the balance of trade constant at its original (period 0) level:

$$\Delta(p^1, u^0, z) \equiv [\Delta : B(p^1 / \Delta, u^0, z) = 0] \quad (5)$$

If new tariffs are equal to zero,  $(1/\Delta - 1)$  is the uniform tariff which is equivalent in efficiency to the original trade policy. More generally,  $1/\Delta$  is the scalar factor of proportionality by which period 1 prices would have to be adjusted to ensure balanced trade when utility is at period 0 level. Notice that this is not the same as raising tariffs by a uniform proportionate rate (except when we deal with a full liberalisation).

Since  $\Delta$  deflates period 1 prices and quantities to attain period 0 utility, it is a compensating variation type of measure. The purpose of any compensating variation index number of border policies is to consistently map some alternative setting of tariffs and quotas into a uniform tariff and quota setting which supports the base level of utility. Under certain conditions that will be discussed later, the TRI provides a consistent measure that is monotonically related to efficiency for all comparisons of possible alternative border policy settings.

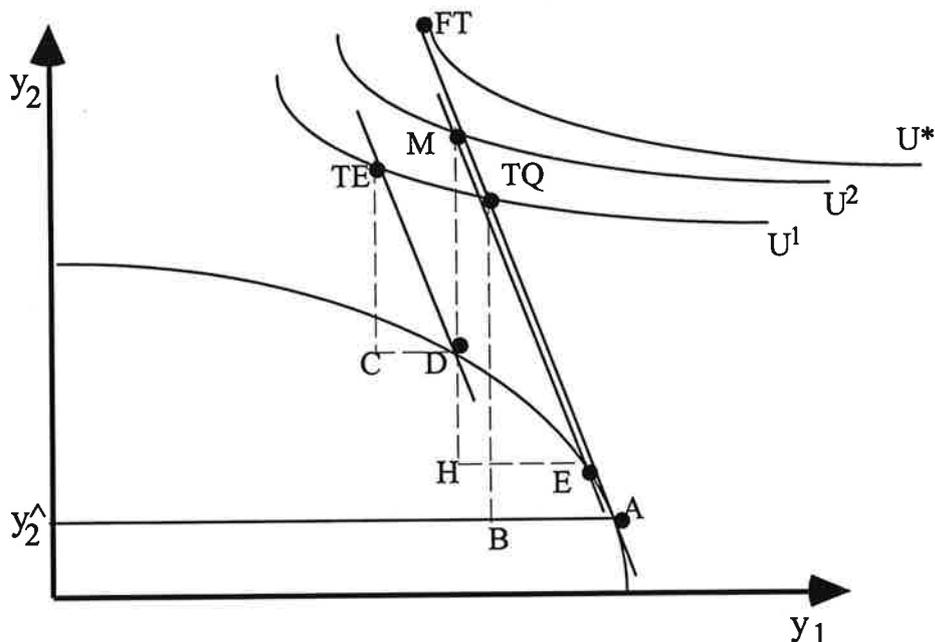
Although the TRI focuses on a crucial dimension for economic analysis, namely the impact on domestic welfare, it is important to notice that the concept of "trade restrictiveness" assumed in the definition of the TRI is a very precise (and limited) one. It is related, but nonetheless very different from the one that could be considered, for example, in the context of trade negotiations. In that case, the trade volume displacement due to a certain set of policies may very well be more relevant to cross-country comparisons than the effects on domestic welfare.

Figure 3.2 provides a graphical example of the differences in terms of trade volumes resulting from alternative definitions of trade restrictiveness (Salvatici et al., 1999). We consider a partially decoupled set of policies that includes a tariff and a production quota fixed exactly at the same level of production which would have occurred under free trade.

In the quantity space of a two-good economy  $(y_1, y_2)$ ,  $A$  is the production bundle and  $FT$  is the consumption bundle under free trade. As a consequence of the introduction of the tariff-cum-quota set of policies, the consumption bundle shifts from  $FT$  to  $TQ$ , while the production quota  $y_2^A$  does not allow the production bundle to change. On the other hand, if we replace the tariff-cum-quota with a tariff equivalent in terms of welfare (that is, the type of counterfactual experiment used in the construction of the TRI), the economy will produce at  $D$  and consume at  $TE$ . Clearly, in the latter case

both imports ( $TE-C < TQ-B$ ) and exports ( $D-C < A-B$ ) are lower than under the tariff-cum-quota case, although the economy is on the same indifference curve  $U^1$ .

**Figure 3.2. Comparison between different tariff equivalents**



It is possible to draw the tariff-equivalent in terms of the volume of trade for the tariff-cum-quota set of policies, obtaining the point  $E$  and  $M$  where, by construction,  $M-H = TQ-B$  and  $H-E = B-A$  (in this case, however, the level of welfare achieved by the two policies is different, with  $U^2 > U^1$ ).

### 3.2.3.2. The MTRI

A trade restrictiveness index which employs a reference point different from welfare is the MTRI, since it operationalises the idea of finding a uniform tariff which yields the same trade volume as the original tariff structure. The definition of the MTRI shares the same basic assumptions of the TRI: single representative agent, small country, perfect competition, and constant returns to scale. The MTRI relies on the idea of evaluating trade policy using trade volume as the reference standard. As a matter of fact, the MTRI is equal to the uniform price deflator ( $\mu$ ) which, when applied to the new set of distorted prices,  $p^1$ , yields the same trade volume (at world prices) as in the initial equilibrium ( $M^0$ ):

$$\mu(p^1, M^0, B^0) \equiv [\mu : M(p^1 / \mu, p^*, B^0) = M^0 = M(p^0, p^*, B^0)] \quad (6)$$

The scalar import volume function  $M$  is defined as:

$$M(p, p^*, B) \equiv \sum_{i=1}^N p_i^* I_i^m \quad (7)$$

where  $I^m$  denotes the uncompensated (Marshallian) import demand function. If  $p^I$  equals its free trade values  $p^*$ ,  $(1/\mu - 1)$  is the uniform tariff ( $\tau$ ) which yields the same volume (at world prices) of tariff restricted imports as the initial vector of (non uniform) tariffs. Accordingly, the MTRI uniform tariff  $\tau$  would lead to the same volume of imports (at world prices) as the one resulting from the uneven tariff structure denoted by the  $N$  dimensional tariff vector  $t$  whose elements are  $t_i$ . That is:

$$\sum_{i=1}^N p_i^* I_i^m [p^* (1 + \tau), B^0] = \sum_{i=1}^N p_i^* I_i^m [p^* (1 + t_i), B^0] \quad (8)$$

The MTRI can be computed by solving equation (8) for  $\tau$ .

The MTRI derived from (8) provides a measure of trade restrictiveness relative to a free trade reference. If we want focus on the change in the tariff structure, from the initial equilibrium corresponding to the price vector  $p^0 = p^* (1 + t^0)$  and the new (still distorted) equilibrium corresponding to the price vector  $p^1 = p^* (1 + t^1)$ , rather than free trade, we define the "uniform tariff surcharge"  $\nu$  which, when applied to the prices in the new equilibrium,  $p^1$ , yields the same volume (at world prices) of tariff restricted imports as the old equilibrium  $M^0$  (Anderson and Neary, 1999). Formally:

$$\nu : M[(1 + \nu)p^1, B^0] = M^0 = M(p^0, B^0) \quad (9)$$

While the levels of TRI and MTRI are most interesting for policy analysis, comparing their levels is very demanding in terms of data. In the two first stages of the following empirical analysis, then, we follow a "local approach" estimating changes in  $\Delta$  and  $\mu$  resulting from the different patterns of tariff reductions (Bureau, Fulponi and Salvatici, 2000).

### 3.2.3.3. Rates of change in the TRI and MTRI

Looking at the definitions of the TRI and MTRI in implicit form provided in equations (5) and (6), it appears that proportional changes in the indices can be expressed as weighted averages of the proportional changes in domestic prices, that is:

$$\dot{\mu}, \dot{\Delta} = \sum_{i=1}^N \sigma_i \dot{p}_i \quad (10)$$

where the point above a variable denotes a proportional change.<sup>7</sup> Obviously, the weights  $\sigma_i$  in equation (10) will be different for each index. For the TRI, the weights turn out to be the share of marginal deadweight loss due to each tariff, and these depend on the partial derivatives of the balance of trade function with respect to prices, that is:

$$\sigma_i^{Tri} = \frac{\partial B}{\partial p_i} p_i / \left( \sum_{j=1}^N \frac{\partial B}{\partial p_j} p_j \right) \quad (11)$$

Clearly, the marginal cost of tariffs is positive if tariff increases have a negative effect on welfare.

In the case of the MTRI, proportional price changes are weighted by their marginal volume shares:

$$\sigma_i^{Mtri} = \frac{\partial M}{\partial p_i} p_i / \left( \sum_{j=1}^N \frac{\partial M}{\partial p_j} p_j \right) \quad (12)$$

The rates of changes in TRI and MTRI can be interpreted as follows. Assume that between period 0 and period 1, all tariffs are reduced, though not all by the same percentage. We move from a protected structure where  $p_i^0 > p_i^*, \forall i$  to a less protected structure where  $p_i^0 \geq p_i^1 \geq p_i^*, \forall i$ . In order to compensate for the change in the tariff structure, it is necessary to impose a uniform tariff, which would raise prices to the point that would restore welfare or the volume of imports to their initial levels (that is, before the change in the tariff structure). The introduction of the uniform tariff surcharge implies that  $\Delta$  or  $\mu$  must be less than 1. This means that the reduction in trade distortions and market protection is signalled by a reduction in the TRI and MTRI, respectively.<sup>8</sup>

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<sup>7</sup> Totally differentiating equation (5) for a given reference level of utility  $u^0$  gives the effect on the TRI of changes in the period 1 distortions,  $\Delta B_p' dp - B_p' p d\Delta = 0$ , which can be readily converted to an expression in terms of proportional changes. Starting from equation (6), an expression for the proportional rate of change of the MTRI can be easily derived along the same lines.

<sup>8</sup> Formally, using the Implicit Function Theorem, the following can be shown to hold:

$$\frac{\partial \Delta}{\partial p_i} = - \frac{\partial B / \partial p_i}{\partial B / \partial \Delta} \quad ; \quad \frac{\partial \mu}{\partial p_i} = - \frac{\partial M / \partial p_i}{\partial M / \partial \mu}$$

Since the numerator and denominator of these expressions are of opposite signs,  $\Delta$  and  $\mu$  decrease as tariff reductions reduce the difference between domestic and world prices.

### 3.3. Empirical implementation of the TRI and the MTRI

In the empirical analysis, only the level of the MTRI is computed, while the rates of change in both indices are estimated.

#### 3.3.1. Empirical implementation of the MTRI in absolute terms

For the calculation of the MTRI in absolute terms, we model the consumer's preferences through a Constant Elasticity of Substitution (CES) utility function. Although this functional form imposes rather restrictive separability assumptions, it is widely used in CGE models (Hertel et al, 1997).

We assume that the overall basket of goods can be partitioned into  $J$  aggregates denoted  $j=1, \dots, J$  and that the utility function of the representative consumer is separable on this partition. Hence, it can be written as a sum of  $J$  functions  $\phi_j$ :

$$U(x) = \sum_j \phi_j(u_j(x_j)) \quad (13)$$

That is, the overall utility function  $U$  is built up from lower level sub-utility functions  $u_j$ . Each vector  $x_j$  contains  $N_j$  elements. We assume that  $u_j$  is a CES function in  $x_j$ . We use the popular Armington (1969) assumption that imports are imperfect substitutes of domestic goods. We partition the consumption vector  $x_j$  within the  $j^{\text{th}}$  group into an aggregated domestic good denoted with a suffix  $d$  and  $N_j-1$  traded goods denoted with an index  $i$ . Hence:

$$u_j(x) = \left( b_{dj}(x_{dj})^{\rho_j} + \sum_i b_{ij}(x_{ij})^{\rho_j} \right)^{\frac{1}{\rho_j}}, \quad i=1, \dots, N_j \quad (14)$$

Denoting  $\sigma_j = \frac{1}{1-\rho_j}$  the elasticity of substitution within the  $j^{\text{th}}$  group, the expenditure devoted to each aggregate  $j$  is:

$$e_j(p, u) = \left( \beta_{dj}(p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij}(p_{ij})^{1-\sigma_j} \right)^{\frac{1}{1-\sigma_j}} u_j \quad (15)$$

The parameters  $\beta_{ij}$  can be calibrated to the initial values of the expenditure shares in the base data, when all domestic prices are set to 1. After deriving the indirect utility function by inverting equation (15), the demand functions of each of the  $i=1, \dots, N_j-1$  imported goods can be found by Roy's identity:

$$x_{ij} = \beta_{ij} \frac{p_{ij}^{-\sigma_j}}{\left( \beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} (p_{ij})^{1-\sigma_j} \right)} e_j \quad (16)$$

Denoting  $P_j$  the price index that corresponds to the denominator of the right-hand side, the import volume function for the  $j^{\text{th}}$  aggregate, valued at world prices, is:

$$\sum_{i=1}^{N_j} p_{ij}^* x_{ij} = \sum_i p_{ij}^* \beta_{ij} \left( \frac{1}{P_j \cdot p_{ij}^{\sigma_j}} \right) e_j, \quad i=1, \dots, N_j-1 \quad (17)$$

When the initial total expenditure  $e_j^0$  (expenditures on both domestic and imports in  $j$ ) is used in the expression (17), we obtain the demand function at the initial level of imports. Since the import volume function is homothetic, defining a uniform tariff equivalent requires selecting an untaxed good as a reference.<sup>9</sup> As in Bach and Martin (2001), we solve the problem by taking the domestic good as a numeraire.

The MTRI uniform tariff equivalent  $\tau_j$  for each aggregate  $j$  is found by setting the value of the import volume function with the uniform tariff equivalent equal to the initial value of imports (evaluated at world prices):

$$\sum_i p_{ij}^* \beta_{ij} \left( \frac{P_j^*}{p_{ij}^* (1 + \tau_j)} \right)^{\sigma_j} e_j^0 = \sum_i p_{ij}^* I_{ij}^0 \quad (18)$$

where  $I_{ij}^0$  are the volume of imports in the initial period (i.e., 1995 or 2000 in our numerical applications), and  $P_j^*$  is the price index:

$$P_j^* = \left( \beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} (p_{ij}^* (1 + \tau_j))^{1-\sigma_j} \right)^{-\sigma_j} \quad (19)$$

The uniform tariff equivalent for each aggregate commodity  $j$  is found using an optimisation routine in GAMS<sup>®</sup> package (Brooke et al, 1998), solving for  $\tau_j$  in equations (18) and (19).

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<sup>9</sup> More generally, Neary (1998) shows how the failure to select a reference untaxed good leads to misleading results in the theory of trade policy.

The indicators  $\tau_j$  are by themselves relevant for the analysis of trade policy. In addition, the  $\tau_j$  can be used as aggregate tariffs in any trade model with a commodity aggregation and an import demand structure which is consistent with our assumptions.<sup>10</sup> However, rather than using a full CGE model, we can readily compute an overall MTRI  $\tau$  that corresponds to the uniform tariff that would keep the overall (i.e., on all  $j=1, \dots, N$  sectors) import volume equal to the initial value. This can be obtained by modifying equation (18) as follows:

$$\sum_j \sum_i p_{ij}^* \beta_{ij} \left( \frac{\left( \beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} (p_{ij}^* (1+\tau))^{1-\sigma_j} \right)^{-\sigma_j}}{p_{ij}^* (1+\tau)} \right)^{\sigma_j} e_j^0 = \sum_j \sum_i p_{ij}^* I_{ij}^0 \quad (20)$$

In the same vein, the overall MTRI uniform tariff factor surcharge can be obtained solving for  $\mu$  in equation (21) below:

$$\sum_j \sum_i p_{ij}^* \beta_{ij} \left( \frac{\left( \beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} (p_{ij}^1 (1+\mu))^{1-\sigma_j} \right)^{-\sigma_j}}{p_{ij}^1 (1+\mu)} \right)^{\sigma_j} e_j^0 = \sum_j \sum_i p_{ij}^* I_{ij}^0 \quad (21)$$

### 3.3.2. Empirical implementation of the rates of change in the TRI and the MTRI

Calculation of the percentage change in the TRI and the MTRI requires a number of simplifying assumptions, given the detailed tariff schedules on which the calculations are based.

#### 3.3.2.1. Empirical implementation of the rates of change in the TRI

The derivative of the balance of trade function with respect to domestic prices can be expressed as a function of the (compensated) import elasticity matrix, whose elements are  $\varepsilon_{j,i}^h = \partial \ln I_j / \partial \ln p_i$ .

Assuming that this matrix is diagonal, we obtain:

$$\partial B / \partial p_i = - \frac{(P_i - P_i^*)}{P_i} I_i \varepsilon_i^h \quad (22)$$

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<sup>10</sup> Bach and Martin (2001) discuss the different tariff aggregators that should be used in different components of a CGE model.

The assumption that the matrix of import elasticities is diagonal is a heroic one, required by the impossibility of estimating a full 1500 by 1500 matrix when working at the level of detail corresponding to the URAA tariff commitments (roughly 1500 tariff lines for the agricultural and food sector). By assuming a diagonal matrix we ignore cross-effects. This is clearly a limitation of the study, because we ignore the possibility of "second best results" such as the case where a piecemeal reform decreases welfare because of substitutions between imported goods (see Hatta, 1977). However, the econometric problems are so formidable that similar simplifying assumptions have also been adopted in other partial equilibrium applications of the TRI (Anderson et al., 1995; Fulponi, 1996, even though the latter study uses a few cross price elasticities available in the literature). Using the import elasticities, the change in the TRI can be written as:

$$\dot{\Delta} = \sum_{i=1}^N \frac{p_i \partial B / \partial p_i}{\sum_{j=1}^N p_j \partial B / \partial p_j} \dot{p}_i = \sum_{i=1}^N \frac{(p_i - p_i^*) I_i \varepsilon_i^h}{\sum_{j=1}^N (p_j - p_j^*) I_j \varepsilon_j^h} \dot{p}_i \quad (23)$$

This is the expression used in the actual calculations. Since we focus on the change in the tariff structure between the beginning and the end of implementation period of the URAA (1995 and 2000), the change in the TRI is calculated as follows:<sup>11</sup>

$$\dot{\Delta}_{2000/1995} = \sum_{i=1}^N \frac{(p_i^{95} - p_i^*) I_i^{95} \varepsilon_i^h}{\sum_{j=1}^N (p_j^{95} - p_j^*) I_j^{95} \varepsilon_j^h} \frac{(p_i^{2000} - p_i^{95})}{p_i^{95}} \quad (24)$$

Finally, it was necessary to make assumptions about the parameter values in the year 2000. We assume linear demand functions, thus the slopes remain constant over the period, while an alternative assumption is used in the sensitivity analysis (reported in the appendix).

### 3.3.2.2. Empirical implementation of the rates of change in the MTRI

According to equation (10), the proportional rate of change of the MTRI is equal to:

$$\dot{\mu} = \sum_{i=1}^N \frac{\partial M_i / \partial p_i p_i}{\sum_{j=1}^N \partial M_j / \partial p_j} \dot{p}_i = \sum_{i=1}^N \frac{p_i^* \partial I_i^m / \partial p_i p_i}{\sum_{j=1}^N p_j^* \partial I_j^m / \partial p_j} \dot{p}_i \quad (25)$$

The change in the MTRI is calculated as a function of the uncompensated import demand elasticities  $\varepsilon_j^m$ , that is:

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<sup>11</sup> The final estimates of TRI and MTRI rates of change presented in Table 3.2 are geometric averages of 1995 and 2000 weighted changes between  $p^{95}$  and  $p^{2000}$ .

$$\dot{\mu}_{2000/1995} = \sum_{i=1}^N \frac{p_i^* I_i^{95} \epsilon_i^m}{\sum_{j=1}^N p_j^* I_j^{95} \epsilon_j^m} \frac{(p_i^{2000} - p_i^{95})}{p_i^{95}} \quad (26)$$

Again, we assume that the slopes of the demand functions remain constant over the period.

### 3.3.3. Data and parameters

Price and quantity data required for computing the MTRI in absolute terms and the rates of change in the TRI and the MTRI for the EU and the US were extracted from the database on tariffs and trade (cf. chapter 2).

The computation of the MTRI in absolute terms requires data on total expenditures. These data were taken from the GTAP (Global Trade Project Analysis) version 4 dataset (McDougall et al., 1998). We therefore adopted the commodity GTAP classification as a basis for computing the levels of the EU and US MTRI.

GTAP provides a comprehensive dataset that is widely used in applied analysis, and researchers might be interested in tariff aggregates that match the GTAP classification for simulation purposes. Moreover, the conversion tables from detailed tariff structures (HS-8-digit) to the GTAP sectors are fully available, which makes it possible to aggregate the very detailed list of tariffs of the URAA schedules into a restricted number of products that correspond to the GTAP system of classification. Finally, the dataset provides the information that is necessary for distinguishing between expenditure spent on domestic products and on imports for the various aggregates. It also provides elasticities of substitution  $\sigma_j$  that match the list of aggregates.

The original GTAP dataset distinguishes  $J=20$  agricultural and food aggregate products. In order to include non food other commodities listed in the URAA schedules (mainly agricultural goods listed in chapters 25 to 53 of the HS classification) we defined an extra aggregate, which does not exist in the original GTAP classification (see Table 3.1). We ignored one GTAP sector (raw milk), because there is no trade for the corresponding commodity. Overall, we aggregated 1764 tariff lines in the EU and 1377 tariff lines in the US, at the 8-digit level of the HS classification up to 20 aggregate products described in Table 3.1. It is noteworthy that the number of tariff lines in each commodity aggregate is very uneven. Table 3.1 shows, for example, that there are only three tariff lines in the aggregate "paddy rice", while the aggregate "fruits and vegetable" tariff includes 183 tariff lines listed in the EU schedule.

**Table 3.1. GTAP agricultural commodities and HS-8 tariff lines**

Commodities (raw milk, GTAP code 20, is excluded because of absence of trade)	GTAP Classification	Number of tariff lines EU	Number of tariff lines US
Paddy rice	1	3	3
Wheat	2	3	3
Cereal grains	3	13	12
Vegetables, fruits, nuts	4	183	186
Oilseeds	5	31	16
Sugar cane, sugar beet	6	3	2
Plant based fibers	7	4	7
Other crops	8	111	116
Cattle, sheep, goats, horses	9	14	12
Other animal products	10	73	50
Raw wool, cocoons and hair	12	9	17
Meat: cattle, sheep, goats, horses	19	77	34
Other meat products	20	199	61
Vegetable oils and fats	21	112	70
Dairy products	22	121	118
Processed rice	23	2	3
Sugar	24	10	15
Other food products	25	580	489
Beverages and tobacco	26	87	84
Non-food items (goods listed in URAA, beyond chapter HS 24)	other	130	79

Source: Bureau and Salvatici (2001).

EU and US import elasticities were estimated econometrically. The estimation of these parameters presents a number of problems. Lack of sufficiently long time series data at the level of disaggregation of the tariff schedules (that is the 8-digit level) did not permit the use of rigorous estimation procedures (the EU, for example, adopted the *Nomenclature Combinée*, a local version of the Harmonised System, only in 1987). Import data for a sufficiently long period were available only at the more aggregated levels in the so-called SITC classification; these data (from the OECD's NEXT dataset) were used in the estimation of the elasticities. Consequently, a single import price elasticity is used for the several commodities that compose the aggregates at the 4-digit level.

In addition, because of the large number of commodities, estimation procedures were simplified. Import demand was assumed to depend only on own price and income. Import demand functions were estimated over the period 1973-1996 in double log form by OLS, using data on import quantities,

domestic unit values deflated by the consumer price index (CPI), and real domestic income. This specification yields the Marshallian import demand elasticities that were used in the MTRI's rates of change calculation (equation (26)). These can only be considered approximations to the (compensated) elasticities that should be used in the calculation of the TRI's rates of change (equation (25)). The uncompensated elasticities for food commodities however, should not differ greatly from the compensated ones as the income effects at the 4-digit level are likely to be quite small.

In general, given the method of estimation and data limitations, the elasticities for any particular commodity can only be considered as very crude estimates. Therefore, a sensitivity analysis were carried out in order for checking how responsive are the TRI and MTRI estimates to the magnitudes of import demand elasticities. Results of this sensitivity analysis are reported in the appendix.

### **3.4. Empirical results for the EU and the US**

#### ***3.4.1. Three alternative tariff reduction schemes***

The TRI and the MTRI are used to assess the impacts of the URAA tariff reduction commitments for the UE and the US. However, since we also want to assess the relative effects of reducing the tariff average and the tariff dispersion, we consider two other tariff reduction schemes in addition to the actual UR scheme implemented by both countries. The three simulated scenarios are called "Uruguay Round", "Swiss formula" and "Uniform tariff reduction".

All three scenarios start from the same tariff structure. In other words, the initial vector of domestic prices  $p_i^{95}$  is the same for all scenarios. It is obtained by multiplying each world price  $p_i^*$  (i.e., the average CIF unit value of imports over the period 1994-1996) by the corresponding ad-valorem base tariff retained by the EU and the US for the year 1995 in their respective UR schedules.<sup>12</sup> However, the three scenarios rely on different final vectors of domestic prices  $p_i^{2000}$ . These may be summarised as follows:

- In the "Uruguay Round" scenario, the final vector of domestic prices  $p_i^{2000}$  is the one that results from the implementation of the actual UR tariff reduction provisions. It is obtained by multiplying each world price  $p_i^*$  by the corresponding ad-valorem bound tariff consolidated by the EU and the US for the year 2000 in their respective UR schedules. As we previously explained, the resulting tariff structure reflects the obligation of a 36% non-weighted average reduction, but with no constraints placed on the mix of reductions to achieve the overall average, except that each tariff line must be

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<sup>12</sup> EU and US average CIF import unit values as well as base and bound tariffs are extracted from the database on tariffs and trade described in chapter 2.

reduced by at least 15%. Therefore, in the "Uruguay Round" scenario, the TRI and MTRI measure the actual impact of the URAA in terms of, respectively, welfare and volume of trade.

- In the "Swiss formula" scenario, the final vector of domestic prices  $p_i^{2000}$  is the one that would have resulted from the implementation of a tariff reduction scheme where higher tariffs would have been subject to larger cuts. It is obtained by multiplying each world price  $p_i^*$  by the corresponding ad-valorem tariff with  $t_i^{2000}$  calculated according to the following expression (with  $t_i^{1995}$  the corresponding initial base tariff):

$$t_i^{2000} = Ct_i^{1995} / (C + t_i^{1995}) \quad (27)$$

The parameter  $C$  was chosen to obtain the same non-weighted average reduction of 36% in tariffs as specified in the URAA. This led in practice to choosing  $C=34$  for the EU and  $C=12$  for the US. This approach, known as the "Swiss formula", was used in the Tokyo Round for manufactured goods.<sup>13</sup> In the "Swiss formula" scenario, the TRI and MTRI reflect the impact of commitments that would have focused more on reducing tariff dispersion than the actual URAA tariff cuts.

- In the "Uniform tariff reduction" scenario, the final vector of domestic prices  $p_i^{2000}$  is the one that would have resulted from the implementation of a uniform 36% tariff reduction for all tariff lines. It is obtained by multiplying each world price  $p_i^*$  by the corresponding ad-valorem tariff with  $t_i^{2000}$  equal to the 36% reduced base tariff. This reduction scheme obviously results in the same average reduction as specified under the URAA, but it does not permit countries to allocate the adjustment across commodities. In the "Uniform tariff reduction" scenario, the TRI and the MTRI measure the impact of reducing the mean tariff without changing the tariff dispersion.<sup>14</sup>

### ***3.4.2. Impact of the Uruguay Round and counterfactual scenarios: Analysis in terms of TRI and MTRI rates of change***

Table 3.2 presents the estimated rates of change in the TRI and the MTRI resulting from the implementation of the three scenarios (each scenario making it possible to achieve a 36% average

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<sup>13</sup> In the Tokyo Round, one parameter,  $C=16$ , was used for all countries. We did not retain this option since we want to isolate the effect of reducing tariff dispersion. Hence, we calibrated  $C$  so that the "Swiss formula" scenario results in the same average reduction than both other scenarios.

<sup>14</sup> One may underline that in all three scenarios, world prices are assumed to be constant. As a result, the measure focuses on changes in tariffs *ceteris paribus*, and is not affected by exogenous price variations.

aggregate tariff reduction). The larger the decrease in the TRI, the more distortions affecting welfare were reduced. The larger the decrease in the MTRI, the more domestic market access increased.<sup>15</sup>

Table 3.2 also reports traditional measures of tariff reductions using weighted and non-weighted averages, for each of the three scenarios. The comparison of the TRI and MTRI with a widely used indicator, the Trade-Weighted Tariff (TWT) average reduction (defined by equation (28) below) makes it possible to assess whether the latter provides a good approximation to the theoretically consistent indices. We also compare the TRI and MTRI to the Trade-Weighted Tariff Factor (TWTF) average reduction (defined by equation (29) below).

$$TWT_{2000/1995} = \sum_{i=1}^N \frac{p_i^* I_i^{95}}{\sum_{j=1}^N p_j^* I_j^{95}} \cdot \frac{(t_i^{2000} - t_i^{95})}{t_i^{95}} = \sum_{i=1}^N \frac{p_i^* I_i^{95}}{\sum_{j=1}^N p_j^* I_j^{95}} \cdot \frac{(p_i^{2000} - p_i^{95})}{p_i^{95} - p^*} \quad (28)$$

$$TWTF_{2000/1995} = \sum_{i=1}^N \frac{p_i^* I_i^{95}}{\sum_{j=1}^N p_j^* I_j^{95}} \cdot \frac{(T_i^{2000} - T_i^{95})}{T_i^{95}} = \sum_{i=1}^N \frac{p_i^* I_i^{95}}{\sum_{j=1}^N p_j^* I_j^{95}} \cdot \frac{(p_i^{2000} - p_i^{95})}{p_i^{95}} \quad (29)$$

Note that, unlike the TWTF change, the TWT change given in equation (28) is not a function of proportional changes in domestic prices. It is therefore fundamentally different from the MTRI and TRI expressions (24) and (26).

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<sup>15</sup> In the rest of the text, we simply refer to the indicators for simplicity, it being understood that they refer to their percentage change.

**Table 3.2. Estimated tariff reduction indices under the three scenarios (percentage changes)**

<b>URUGUAY ROUND</b>	<b>US</b>	<b>EU</b>
Non-weighted average tariff reduction	-36.6	-38.3
Non-weighted average tariff factor reduction	-2.6	-6.6
Trade-weighted tariff reduction (TWT)	-24.8	-33.9
Trade-weighted tariff factor reduction (TWTF)	-0.9	-4.5
TRI	-2.7	-12.4
MTRI	-1.0	-5.7
<b>SWISS FORMULA</b>		
Non-weighted average tariff reduction	-36.2	-37.9
Non-weighted average tariff factor reduction	-5.4	-10.5
Trade-weighted tariff reduction (TWT)	-13.8	-24.6
Trade-weighted tariff factor reduction (TWTF)	-1.1	-8.4
TRI	-4.4	-25.5
MTRI	-1.1	-10.6
<b>UNIFORM TARIFF REDUCTION</b>		
Non-weighted average tariff reduction	-36.0	-36.0
Non-weighted average tariff factor reduction	-3.3	-7.1
Trade-weighted tariff reduction (TWT)	-36.0	-36.0
Trade-weighted tariff factor reduction (TWTF)	-1.0	-5.0
TRI	-3.8	-16.6
MTRI	-1.0	-6.3

Source: Bureau, Fulponi and Salvatici (2000).

Results reported in Table 3.2 may be synthesised in seven main points:

- i) Under the "Uruguay Round" scenario, the non-weighted tariff reduction exceeds the trade-weighted one for both the EU and the US. This suggests that under the URAA, both countries implemented larger reductions for those goods that had smaller import flows. The same is true for tariff factor changes.
- ii) The TRI and MTRI estimated under the "Uruguay Round" scenario indicate that the UR tariff provisions resulted in an increase in both domestic welfare and market access in the EU and the US (remember, however, that we ignored possible import substitutions that could have resulted in a decrease in welfare).
- iii) The percentage changes in TRI, MTRI and TWTF obtained by the EU are much larger in absolute terms than those of the US. We can explain this by noting that the initial tariff structure of the EU has a larger mean and greater variance and these characteristics should imply higher initial values for both

the TRI and MTRI. This is confirmed, at least for the MTRI, by the results presented thereafter in Tables 3.3, 3.4 and 3.5.

iv) Under the "Swiss formula", the fact that the non-weighted average tariff and tariff factor reductions exceed the trade-weighted ones is not surprising, since in this case, the largest reductions are applied to the highest tariffs, which are often those applied to the smallest import flows. Though the difference between the two averages is much larger in the US case, it should be recalled that the formulas used in the calculations are different (the parameter *C* differs).

v) The comparison of the rates of change in the TRI obtained under the "Swiss formula" and the "Uruguay Round" scenarios suggests that both the US and the EU would have reaped larger benefits in terms of welfare using the Swiss formula reduction scheme rather than the tariff reduction scheme actually used in the URAA.

vi) The rates of change in the MTRI resulting from both scenarios indicate that in the EU, market access improvement would also have been greater under the Swiss formula reduction scheme compared to the actual URAA situation. In the case of the US, there is less difference between the MTRI rates of change obtained under both scenarios than in the EU. This suggests that, compared to the URAA commitments, additional reductions in tariff dispersion would have had little impact on market access in the US.

vii) Comparing the "Uniform tariff reduction" and the "Uruguay Round" scenarios, it is possible to assess how the EU and the US used their "degrees of freedom" in allocating tariff reduction commitments across commodities and how this "strategic allocation" affects both welfare and market access. Table 3.2 shows that the URAA has increased access to the market in a way that is very comparable to what would have resulted from a uniform tariff reduction. This means that both the EU and the US have not allocated tariff cuts in a very "strategic" way. The results also confirm the finding that the "dilution" of tariff reduction effect was limited in the EU, as it could have expected since most tariffs were cut by 36% and no tariff was reduced by less than 20%. In welfare terms (TRI results), the uniform tariff reduction scheme is not as effective as the Swiss formula scheme. Nonetheless, it leads to a larger increase in welfare than the actual UR commitments. This is explained by the fact that with a uniform reduction we obtain a tariff structure with both a lower mean and dispersion than under the URAA (Tables 3.3 and 3.4 below). These results show that the uneven allocation of the tariff reductions limited the welfare gains that could have been obtained from the Agreement. The difference between the TRI estimates in the URAA and uniform tariff reduction cases measures the magnitude of the welfare costs of the "strategic" allocation of the tariff reductions. This outcome could also be interpreted as a willingness to protect the more politically sensitive sectors.

**3.4.3. Impact of the Uruguay Round and counterfactual scenarios: Analysis in terms of changes in MTRI levels**

Tables 3.3 and 3.4 provide a set of aggregated statistics that allow for characterising the tariff structure in, respectively, the EU and the US prior to implementation of the URAA (i.e., for the year 1995) and at the end of the implementation period of the Agreement (i.e., for the year 2000, under the "Uruguay Round scenario"). This set includes the computed MTRI levels (or MTRI uniform tariff equivalents  $\tau$ ), the non-weighted and trade-weighted average tariffs and the standard deviations of tariffs.

Table 3.5 reports the computed EU and US MTRI levels for each aggregate of the GTAP classification. MTRI levels are calculated for the year 1995 and for the year 2000 under the three considered scenarios.

**Table 3.3. EU aggregate statistics for the years 1995 and 2000**

Tariff structures (ad-valorem equivalent, in percentage)	Non-weighted average tariff (%)	Trade-weighted average tariff (%)	Standard deviation	MTRI level (%)
1995 (base rates)	26.7	25.5	38.6	32.4
2000 "Uruguay Round"	17.9	17.8**	26.8	25.6
2000 "Swiss formula"	11.1	8.4**	7.8	13.4
2000 "Uniform tariff reduction"	17.1	16.3**	24.7	24.7

\*\*weighted by 1995 import values  
Source: Bureau and Salvatici (2000).

**Table 3.4. US aggregate statistics for the years 1995 and 2000**

Tariff structures (ad-valorem equivalent, in percentage)	Non-weighted average tariff (%)	Trade-weighted average tariff (%)	Standard deviation	MTRI level (%)
1995 (base rates)	9.7	3.3	18.3	3.5
2000 "Uruguay Round"	7.1	2.2**	15.5	2.4
2000 "Swiss formula"	3.5	1.7**	3.5	1.9
2000 "Uniform tariff reduction"	6.2	2.1**	11.7	2.4

\*\*weighted by 1995 import values  
Source: Bureau and Salvatici (2000)

**Table 3.5. Computed MTRI uniform tariff equivalents in 1995 and in 2000 under the 3 scenarios**

	Non-weighted average tariff in 1995 (%)		Trade-weighted average tariff in 1995 (%)		MTRI level in 1995 (%)		MTRI level in 2000 (%) "Uruguay Round"		MTRI level in 2000 (%) "Swiss formula"		MTRI level in 2000 (%) "Uniform tariff reduction"	
	EU	US	EU	US	EU	US	EU	US	EU	US	EU	US
Commodities												
Paddy rice	58.6	3.0	80.5	1.7	80.8	1.7	51.9	1.1	23.9	1.5	52.0	1.1
Wheat	57.8	4.9	114.0	4.5	114.0	4.5	73.0	2.9	26.2	3.3	73.0	2.9
Cereal grains	45.6	1.1	84.4	0.8	89.8	0.8	59.9	0.5	24.1	0.7	60.7	0.5
Vegetables, fruits, nuts	16.8	6.9	57.5	4.2	68.9	4.5	58.1	3.0	21.5	2.3	51.6	3.0
Oilseeds	0	23.6	0	4.0	0	6.6	0	5.5	0	2.1	0	5.5
Sugar cane, sugar beet	40.3	2.9	14.2	3.7	14.8	3.7	12.0	2.3	9.5	2.8	9.8	2.3
Plant based fibres	0	11.1	0	2.8	0	2.9	0	1.9	0	1.9	0	1.9
Other crops	7.5	3.7	7.8	1.7	8.0	1.8	3.4	1.2	6.0	1.0	5.3	1.2
Cattle, sheep, goat, horse	30.2	2.1	36.2	0.1	51.5	0.1	38.9	0.1	18.8	0.1	39.4	0.1
Other animal products	4.9	1.1	2.2	0.3	2.6	0.3	1.9	0.2	1.8	0.2	1.9	0.2
Raw wool, cocoons, hair	0.1	3.5	0	5.4	0	5.4	0	3.5	0	3.6	0	3.5
Meat (cattle, sheep, goat, horse)	62.1	7.0	94.0	1.1	103.2	1.1	70.5	0.7	24.9	0.8	70.7	0.7
Other meat products	35.1	4.8	24.7	1.9	26.4	2.0	17.5	1.3	13.6	1.4	17.9	1.3
Vegetable oils and fats	14.5	4.5	5.7	3.1	6.8	3.1	5.3	2.1	4.2	2.1	4.9	2.1
Dairy products	72.0	26.5	69.7	8.1	76.4	11.4	53.0	9.0	23.0	3.0	52.1	9.0
Processed rice	99.2	7.8	126.4	3.4	127.6	3.4	82.3	2.2	26.9	2.6	82.3	2.2
Sugar	39.2	26.0	63.9	13.9	67.5	15.2	55.3	10.4	21.9	5.5	45.2	10.4
Other food products	28.0	11.8	19.7	5.6	23.7	6.0	18.7	4.0	12.6	3.0	17.1	4.0
Beverages and tobacco	15.8	7.2	28.2	2.3	36.7	2.4	25.4	1.6	16.4	1.8	27.0	1.6
Non-food items	8.6	3.0	3.6	2.1	3.7	2.1	1.4	1.4	3.0	1.4	2.4	1.4

Note: All indices compare the actual or a counterfactual tariff structure with free trade.  
Source: Bureau and Salvatici (2001).

First of all, the comparison of Tables 3.3 and 3.4 makes it possible to point out the four following points:

i) The initial tariff structure of the EU has a larger mean and greater variance than the one of the US. In 1995, the non-weighted average tariff is 26.7% in the EU and 9.7% in the US, while the corresponding standard deviations are, respectively, 38.6 and 18.3. This results in a substantially higher initial MTRI value in the EU compared to the US (32.4% and 3.5%, respectively). In other words, the initial level of trade restrictiveness is much higher in the EU than in the US. This explains the larger percentage changes in TRI, MTRI and TWTF obtained by the EU relative to the US, reported in Table 3.2.

ii) The comparison of the MTRI levels in the base period and in the year 2000 under the "Uruguay Round" scenario confirms that the UR tariff provisions increased market access in both the EU and the US. One may underline that under the "Uruguay Round" scenario, the mean and the standard deviation of tariffs decrease in both countries as well. These results are the consequence of the commitment to reduce each tariff by at least 15%.

iii) The "Swiss formula" scenario generates a tariff structure with a lower mean and a smaller standard deviation than the "Uruguay Round" scenario in both countries. Hence, it is not surprising that also the EU and US MTRI levels decrease more following the implementation of the Swiss formula reduction scheme rather than the UR actual one. In the US however there is less difference between the MTRI values than in the EU. This result confirms that market access improvement would have been greater under a Swiss formula reduction scheme than under the actual URAA case in the EU. In the case of the US however, the adoption of a tariff reduction scheme, such as the Swiss formula, that would have focused more on reducing tariff dispersion than the actual URAA tariff cuts would have had little impact on market access.

iv) The "Uniform tariff reduction" scenario also generates a tariff structure with a lower mean and a smaller standard deviation than the "Uruguay Round" scenario. Nevertheless, the decrease in the levels of these statistics relative to the "Uruguay Round" scenario induced by the "Uniform tariff reduction" is relatively low (almost as compared with the one observed with the "Swiss formula" scenario). As a result, the "Uniform tariff reduction" scenario leads to a very limited decrease in the MTRI levels compared to the "Uruguay Round" scenario in both the EU and the US. This result confirms that the EU and the US have not allocated UR tariff cuts in a very "strategic" way, so that in both countries the URAA has increased access to the market in a way that is very comparable to what would have resulted from a uniform tariff reduction.

Secondly, dealing with Table 3.5 makes it possible to analyse the trade impact of the actual UR tariff provisions as well as of the tariff cutting strategies of both the EU and the US at a more disaggregated level. The four following points deserve to be emphasised:

i) Table 3.5 shows that it is not surprising that, in the initial situation, the aggregated non-weighted average tariff and the aggregated MTRI level are lower in the US than in the EU (9.7% vs 26.7% and 3.5% vs 32.4%, respectively) since one may observe lower US non-weighted average tariffs and MTRI levels relative to the EU's ones in nearly all sectors.<sup>16</sup> The only exceptions correspond to three

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<sup>16</sup> The non-weighted average tariffs that are presented here differ significantly from those computed by Gibson et al (2001), even though we use the same initial tariff data, i.e., the WTO schedules. The main difference lies in the convention for converting specific tariffs into ad-valorem equivalents. We use a 4 year average of unit values of either imports or exports (when imports are small or inexistent) at the 8-digit level, while Gibson et al use world prices at a more aggregated level. We believe that with our convention, we minimise the risk of

product categories (oilseeds, fibres and wool) which face zero tariffs in the EU.<sup>17</sup> The gap between the EU and the US non-weighted average tariffs and MTRI levels is particularly wide in the grain (including rice), meat, dairy and sugar (cane and beet) sectors.

ii) Table 3.5 confirms that the actual UR tariff provisions increased market access in both the EU and the US. Indeed, the "Uruguay Round" scenario induces a decrease in the EU and the US MTRI levels, with respect to the initial situation, in each of the 20 considered sectors. Once again, this illustrates the consequence of the commitment to reduce each tariff line by at least 15%.

iii) The comparison of EU and US MTRI levels obtained under the "Uruguay Round" scenario and the "Swiss formula" scenario confirms the result previously mentioned among which the market access improvement would have been greater under the Swiss formula reduction scheme compared to the URAA case in both countries, but to a much larger extent in the EU than in the US. Table 3.5 however allows to further highlight the trade-off between the tariff dispersion and the tariff level. If the Swiss formula had been applied, the Uruguay Round would have led to considerable increase in market access as measured by the MTRI in the EU. More specifically, the Swiss formula implementation would have led to dramatic decrease in trade restrictions in EU highly protected sectors such as grains (including rice), ruminant live animals and meat, dairy and sugar. The US market would also have been more opened at the aggregate level, but there are quite a few instances (mainly dairy and sugar, sugar, meat) where the Swiss formula does perform better than the actual URAA, while this is nearly always the case for the EU. Such results suggest that by using the Swiss formula the EU could have achieved the same market access improvement (or welfare gain) as the one achieved through the URAA, with an average tariff reduction of less than 36%. However, this would have required cutting more dramatically the highest tariffs. This might of course have been difficult, since some tariffs are particularly sensitive from a political standpoint, especially when a significant reduction of the border protection would require a drastic reform of the corresponding Common Market Organisation.

iv) The comparison of EU and US MTRI levels obtained under the "Uruguay Round" scenario and the "Uniform tariff reduction" scenario also confirms the result already mentioned among which the "dilution" of tariff cuts has had overall a limited impact on market access in both the EU and the US. However, if we compare, in Table 3.5, the ranking of sectors according to the initial MTRI levels with

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constructing artificial tariff peaks, which is often the case when one converts specific tariffs into ad-valorem using reference prices for more aggregated commodities. It is also worth recalling that the US schedule includes specific tariff lines for in-quotas tariffs (in the case of commodities subject to a tariff-rate quotas). These tariff lines were excluded from our analysis.

<sup>17</sup> Table 3.5 shows that three product categories in the EU face zero tariffs while all aggregate tariffs in the US face a strictly positive average tariff. However, this mainly reflects the particular structure of the GTAP classification. Overall, the original 1995 EU tariff schedule included 245 lines with zero tariffs, while the US schedule included 303 lines with zero tariffs. If we focus only on those items with non-zero tariffs, the average non-weighted base tariff was 12.7% in the US and 31.4% in the EU.

the ranking resulting after the URAA implementation, there is evidence of a more "strategic" allocation of tariff cuts by the EU. Table 3.5 shows that there is only one change in the US (wheat trading place with vegetables, fruits and nuts), while there are quite a few changes in the EU, where vegetables, fruits and nuts, sugar, other food products, vegetable oils and fats and other animal products gain positions, while paddy rice, dairy, other meat products, other crops and non-food items move down in the ranking.

Finally, if we want to check the consistency of the numerical results with those presented in Table 3.2, we need to turn the MTRI-uniform tariff surcharges as indicated in equation (9). The results for the aggregate agricultural and food products are presented in Table 3.6.

**Table 3.6. MTRI-uniform tariff surcharges (absolute values)**

	European Union			United States		
	Uruguay	Swiss	Uniform	Uruguay	Swiss	Uniform
v	5.4	16.8	6.2	1.0	1.3	1.0

Note: All tariff indices compare the initial (1995) tariff structure with the new (2000) ones.  
Source: Bureau and Salvatici (2001).

Given the differences in the methodological approaches followed for the computation of the tariff surcharge and of the MTRI rate of change, the results are surprisingly similar. Only in the case of the Swiss Formula, the difference is substantial, especially in the case of the EU. This is the scenario that implies the largest change in tariffs: in such a case, then, the higher substitutability implied by the CES functional form leads to a higher impact.<sup>18</sup>

### 3.5. Conclusion: Discussion and policy recommendations

#### 3.5.1. How reliable are the *a-theoretic* indicators?

From the results in Table 3.2, it is obvious that any attempt to measure the impact of trade liberalisation through synthetic indicators should use changes in tariff factors. Changes in the level of tariffs do not correctly reflect the impact of trade reforms on the economy. For example, if one focuses only on the trade-weighted tariff reduction, one would conclude that the Swiss formula would be less effective than actual Uruguay Round commitments, while the theoretically consistent indicators show the opposite both in terms of trade and welfare. On the contrary, the average tariff factor reductions provide a consistent ranking of the different tariff reduction schemes. This is not surprising, since the

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<sup>18</sup> It should be recalled that Bureau, Fulponi and Salvatici (2000) assume linear import demand functions and a diagonal matrix of import elasticities.

TRI and the MTRI changes are also weighted averages of tariff factors. Focusing on tariff factors allows us to account for the obvious fact that a 50% reduction in a 2% tariff rate does not reduce protection as much as reducing a 40% tariff by 50 % (Finger and Schuknecht, 1999).<sup>19</sup> A similar percentage tariff reduction can have very different impacts on market access and welfare between countries with a different initial tariff structure.

An interesting observation is that the difference between the TRI and the TWTF (Trade-Weighted Tariff Factor) reductions is considerable in Table 3.2. Comparing expressions (24) and (29), the weights of the TRI include the factors  $(p_i - p_i^*)$ , which magnify the effect of the uneven tariff structure. In the TWTF, the reductions in high initial tariffs have weights that are smaller than in the TRI. That is, the TWTF under-estimates the welfare change effect that is related to the variance of the tariff structure (Anderson, 1995, shows how the welfare change due to a tariff shift is related both to the mean and to the variance of the tariff structure).

On the other hand, results reported in Table 3.2 show that the change in the TWTF is able to mimic the change in the MTRI. This suggests that the TWTF is a decent indicator of the trade impact of a tariff reduction, at least under our assumptions. This can be explained looking at equations (26) and (29) which show that the MTRI rate of change corresponds to the TWTF reduction if the uncompensated import demand elasticities are equal across commodities (i.e.,  $\varepsilon_j^m = \varepsilon^m, \forall j$ ).

The empirical finding in Table 3.2, are confirmed by Table 3.5 which shows significant differences between the MTRI uniform tariffs (or levels) and the non-weighted average tariffs, while the values for the trade-weighted average tariffs are often quite close to those given by the MTRI uniform tariffs. This empirical finding converges with those of Anderson and Neary (1999) and Bach and Martin (2001) who show that the trade-weighted average tariff is a linear approximation to the tariff aggregator based on the expenditure function. In other terms, the trade-weighted average tariff plays the same role as the Laspeyres price index in consumer theory, providing a fixed-weight approximation that underestimates the "true" height of tariffs because it neglects substitution induced by tariff changes.

This empirical finding can be explored a bit further in the particular case of a CES aggregator function, where the trade-weighted average tariff corresponds to constant expenditure shares. Constant shares correspond to the special case of a Cobb-Douglas sub-utility function, where  $\sigma_j=1$ . In such a case, it can be shown that in the base equilibrium (that is, with all domestic prices equal to 1), the

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<sup>19</sup> Both reductions would be equal to 50% in terms of tariff changes, while computing the tariff factor changes we would obtain less than 1% when a 2% rate is cut in half, and more than 14% when a 40% rate is cut in half.

MTRI uniform tariff coincides with the trade-weighted average tariff (Bureau and Salvatici, 2001). This proposition clarifies the linkage between our MTRI estimates, using a CES aggregator function, and the trade-weighted index. Since the values of the  $\sigma_j$  in the GTAP dataset rank between 2.2 and 3.8, it is not surprising that the MTRI for the aggregate level is sometimes close to the value of the trade-weighted average tariff.

However, the MTRI uniform tariff is more likely to be higher than the trade-weighted average tariff the more elastic is the demand for tariff-constrained imports. On the basis of empirical calculations with a CGE model, Anderson and Neary (1999) are able to confirm this basic insight. Our empirical use of the MTRI in order to construct sectoral tariff aggregates leads to similar conclusions.<sup>20</sup> In the specific case of a CES aggregator function, it can be shown that the MTRI uniform tariff exceeds the trade-weighted index, when the elasticity of substitution of the CES aggregator function is greater than 1 (Bureau and Salvatici, 2001).

Looking at Tables 3.1 and 3.5, it is also obvious that the MTRI uniform tariff and the trade-weighted index give very similar results when the number of tariff lines in the aggregate is very small, or when there is little dispersion in tariffs within an aggregate. For the aggregates with a large number of products, the gap between the two indices can be very large. In the dairy sector (which aggregates 121 tariff lines in the EU and 118 in the US), for example, the trade-weighted average tariff underestimates the trade restrictiveness (as measured by the MTRI uniform tariff) of the pre-URAA tariff structure by 29% in the US and by 9% in the EU. This is also the case in the cattle sector and in the beverages sector in the EU (underestimation of 29% and 23%, respectively), and in the oilseed sector in the US (underestimation of 40%). Overall, in the EU, for six aggregate products out of twenty, the trade-weighted average underestimates the MTRI uniform tariff by more than 10%.

In brief, the trade-weighted average tariff can be a satisfactory approximation of more theoretically consistent indicators of market access only under very specific conditions, and for specific values of the substitution elasticities. In more general cases, when the aggregate includes a large number of heterogeneous tariff lines and when the substitution elasticities differ from unity, the trade-weighted average is a poor indicator of the restrictiveness of the tariff structure.

Finally, the difference that we observe between the MTRI uniform tariff and the non-weighted average tariff suggests that CGE or trade models that rely on aggregate tariffs constructed as simple averages,

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<sup>20</sup> More precisely, Anderson and Neary proved the following proposition: "The MTRI uniform tariff exceeds the trade-weighted average tariff if: (i) the compensated arc elasticity of demand for the composite tariffed good exceeds one; (ii) the composite tariffed good is normal; and (iii) the trade expenditure function is implicitly separable in tariffed and other goods." (Anderson and Neary, 1999).

use poor estimates of the actual tariff structure. This bias is likely to affect a large number of studies, since it is common practice to construct aggregate tariffs as simple averages of the detailed tariffs applied by custom officers, who sometimes work at a level of details corresponding to the HS10 or HS12-digit level (case of the European Union). Constructing the aggregate tariffs used in CGE or trade models as trade-weighted averages is obviously more satisfactory. However when one aggregates a large number of goods with a large tariff dispersion into a single commodity, this method also results in significant bias, most of the time an underestimation of the aggregate tariff, as measured by the MTRI uniform tariff.

### ***3.5.2. Policy implications***

The results presented in this chapter should be used with some caution in policy analysis.

The TRI and the MTRI are the correct way to measure the economic consequences of tariff barriers, under a certain number of restrictive assumptions. These assumptions allowed us to measure the impact of various tariff reduction schemes on economic efficiency and on the volume of imports for the EU and the US, but they should be kept in mind when interpreting the results, since they may not hold in reality. This is obviously the case for the small country assumption. The theoretical assumptions underlying the construction of the trade balance functions (single utility-maximising consumer, competitive markets) are often made, but are nonetheless restrictive. In the computation of the rates of change, we ignored the substitutions and complementarities that may exist between imports; while in order to be able to compute the MTRI level we needed to assume a specific functional form for import demand.

On the empirical side, figures used for the year 2000 do not give a proper image of trade restrictiveness of agricultural trade policy in the US and the EU. The main reason is that, for the purpose of comparison between scenarios, the world prices were kept the same as in the initial (1995) situation. In addition, we did not account for policy changes, particularly in the EU, like the fall in the intervention price for grains that has an effect on the level of tariffs (the entry price capped to 155% of the intervention price). Moreover, the actual protection of EU agriculture is clearly overestimated since we focused on the MFN tariffs. That is, we ignored preferential tariffs that account for roughly 50% of the value of EU imports. Imports under regional agreements face very small tariffs in general, and in-quota tariffs are roughly around one third of the corresponding MFN tariffs in the EU (see Bureau and Tangermann, 2000). Finally, as already mentioned, given the method of estimation and data limitations, import elasticities used in our empirical application can only be considered as very crude estimates. On this point however, the sensitivity analysis that was carried out indicates that alternative assumptions on the elasticity values do not significantly modify the outcomes (cf. appendix).

Nevertheless, the results make it possible to refine the analysis of the impact of the Uruguay Round on market access.

First, while the relative change results suggested that the Uruguay Round had led to a larger increase in market access in the EU than in the US, relative to the pre-Uruguay Round situation, the computation of the absolute level of the MTRI uniform tariffs shows that access to the EU market is still far more restricted than the US one, at least for countries that do not benefit from a preferential treatment. This is the case for all GTAP commodities aggregate (except plant base fibres). The difference in market access level is particularly large for grains and meat, but is still significant for those commodities that are protected by relatively high tariffs in the US, such as dairy products and sugar.

Computing the absolute level of the MTRI uniform tariffs leads to reconsider dramatically the image of the relative rates of protection of the EU and US agricultural sector. Indeed, on a non-weighted basis, the overall average tariff on agricultural and food products was 26.7% in the EU and 9.7% in the US in 1995, while the trade-weighted average tariff was respectively 25.5% in the EU and 3.3% in the US. On the other hand, the MTRI uniform tariffs measure a degree of trade restrictiveness of 32.4% for the EU and 3.5% for the US. That is, the difference between the MTRI uniform tariff and the non-weighted average tariff is much larger in relative terms (and of opposite sign) in the case of the US than in the case of the EU. This suggests that the high tariffs in the US apply on a restricted set of very particular goods, most of them being imported in small quantities. In point of fact, very high tariffs are concentrated on specific types of processed food (peanuts, preparations with meat or processed vegetables). High tariffs are also set on dairy products, but the bulk of imports, namely tropical products and live animals that accounts for large import values faces almost zero tariffs. By contrast, most of the commodities imported in large quantities in the EU face significant tariffs, at least under MFN treatment.

Secondly, our results suggest that the strategy of tariff reductions implemented in both the US and the EU, with a selective differentiation of tariff cuts across commodities, limited the welfare gains that could have been reaped by the Agreement. However, this strategic allocation of tariff cuts has not significantly prevented market access improvements. The comparison of the MTRI in the "Uruguay Round" and "Uniform tariff reduction" scenarios shows that the uneven allocation of tariff cuts had a limited effect in the EU. Thus, the market access effects of the UR provisions are not very different from those resulting from a uniform 36% reduction in tariffs. This suggests that partner countries have not suffered from this uneven allocation. The limited impact of the uneven allocations of tariff cuts, as measured by the MTRI, might be explained by the fact that the EU did not use its degrees of freedom for allocating tariff cuts in a very strategic way. All EU tariff reductions were at least 20%, and 665

tariff lines (i.e., roughly half of the total number of tariff lines) experienced a 36% decrease. This is in contrast to most other countries that appear to have applied only a 15% reduction to their most sensitive products and that display a greater variance in their tariff rate cuts.

The US schedule shows more variability in cuts across tariff lines. However, a comparison of the reductions in the MTRI across all the three considered scenarios, each hovering around 1 per cent, suggest that the "strategic" allocation of tariff cuts in the US has not had a major influence on market access either. The explanation lies in the initially low tariffs for most commodities. With initial low levels of protection, the US choice of a particular tariff cutting formula does not make much difference to the results. The choice of any specific tariff cutting procedure matters less here than in countries where the tariff structure is initially more distorting. In this respect, one might expect that the United States is unlikely to resist adopting one formula rather than another in the next round of negotiations. This also means that third country exporters to the US market would also not gain much from any particular option. The EU tariff structure suggests that the choice of a particular tariff cutting formula makes a greater difference to the EU than to the US, and may be more of a contentious issue if market access is a major objective.

Thirdly, the use of the TRI/MTRI concepts also sheds light on the relative importance of reducing the average tariff and tariff dispersion. The TRI changes under counterfactual scenarios leading to a lower coefficient of dispersion of tariffs suggest that the EU and US would have experienced larger welfare gains if such tariff reduction schemes had been retained rather than the one resulting from the actual UR commitments.<sup>21</sup> Results for the MTRI in the EU also show that market access would be increased significantly if most protected commodities were subject to larger tariff cuts. In the next round of negotiations, proposals for tariff cutting schemes that set an identical tariff on large groups of commodities ("tariff bands"), or proposals for binding tariffs at a 4 or 6-digit level of the classification would contribute to reduce dispersion. They deserve more attention in the Millennium Round.

Finally, one may acknowledge that it is difficult to envisage the actual use of the TRI and/or MTRI in order to express tariff reduction commitments in future rounds of negotiations. These indices are too demanding in terms of data requirement, and their complexity makes them less appealing to policy makers than simple trade-weighted averages. Even if the theoretically sound indices are not explicitly used to express commitments, they can provide a benchmark for evaluating more readily computable tariff indices. In this respect, our results show that the trade-weighted average tariff factor reduction

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<sup>21</sup> The welfare gains depend on substitutions between commodities that we ignored in this study. Note however that the sign of the overall effect of the substitution is ambiguous. Accounting for substitutions could show either smaller welfare gains or show even larger gains when dispersion is reduced depending on the goods that are complements and substitutes, and the magnitude of the tariffs to which they are subject.

could be a proxy for assessing market access improvements (although it would clearly under-estimate the welfare impact). It is clear, however, that commitments expressed in average tariffs (rather than tariff factors) are less meaningful, when one focuses on market access improvement.

## APPENDIX

### Sensitivity analysis

As the TRI and MTRI use elasticities as weights in the aggregation procedures, it is necessary to ask to what extent these parameters may affect our MTRI/TRI estimates. Previous work on the TRI and percentage change in the TRI indicates that alternative assumptions on the elasticity values did not significantly modify the outcomes (Anderson and Neary, 1994; Fulponi, 1996). Nonetheless, we undertook a limited number of sensitivity tests to examine the possible effects of different elasticity values on the measurement of TRI/MTRI changes. Elasticities were drawn at random from a uniform distribution for each commodity. The parameters of the distribution were set at the minimum and maximum levels obtained from estimations, i.e., [-0.2,-2.5].<sup>22</sup> For both the US and the EU, 100 draws of each elasticity were done and the changes in MTRI/TRI calculated. The results of the experiments are shown in Table 3.7. Average values and standard deviations of the 100 experiments for each indicator are presented.

**Table 3.7. Sensitivity tests of the computed TRI and MTRI rates of change to import demand elasticities** (Mean values and standard deviations of TRI and MTRI rates of change in percentage, based on 100 estimates with elasticities drawn from a uniform distribution)

	European Union			United States		
	Uruguay	Swiss	Uniform	Uruguay	Swiss	Uniform
TRI-constant slope	-12.40 (-0.39)	-26.61 (-2.41)	-17.39 (-0.82)	-2.23 (-0.12)	-4.90 (-0.44)	-4.39 (-0.34)
TRI-constant elasticity	-12.21 (-0.37)	-23.80 (-2.13)	-16.42 (-0.84)	-2.21 (-0.12)	-4.67 (-0.41)	-4.31 (-0.33)
MTRI	-4.29 (-0.28)	-7.79 (-1.02)	-4.73 (-0.45)	-0.91 (-0.06)	-1.11 (-0.10)	-0.94 (-0.06)

Source: Bureau, Fulponi and Salvatici (2000).

Compared to the results of Table 3.2, we find that average values differ by about 15-20 per cent compared to the "base" calculations in almost all cases, except for the EU-MTRI where the average values are about 35 per cent lower. The rankings of the alternative tariff-cutting formulas are

<sup>22</sup> In the normal case, the income effect reinforces the substitution effect, so that in absolute value the own-price Marshallian elasticity could provide an upper bound for the sensitivity analysis. Due to the poor data availability at the level of the commodity detail appearing in the schedules, the upper bound of the interval used in the sensitivity analysis was set at a slightly higher level than the average maximum estimated Marshallian elasticities.

preserved for all indicators. Overall, we find that the percentage changes in the indices are not significantly affected by the values of elasticities.<sup>23</sup>

In terms of sensitivity to the import demand functional form, we computed an alternative form of the TRI rate of change. Rather than assuming a linear demand function, we assumed an hyperbolic import demand, so that the elasticities were constant between 1995 and 2000, rather than slopes. Table 3.7 confirms that the results are not fundamentally affected by the choice of a particular functional form.<sup>24</sup>

As far as the MTRI uniform tariff computation is concerned, since our results are based on unsophisticated estimates of substitution elasticities (the ones taken out of the GTAP dataset), it is necessary to ask to what extent these parameters may affect the computed MTRI levels. In Table 3.8 we compute the overall MTRI uniform tariff equivalents making different assumptions about the values of the substitution elasticities. The elasticities are assumed to range from one third to three times the original values.

**Table 3.8. Sensitivity of MTRI uniform tariff estimates to alternative assumptions on the values of the elasticities of substitution**

	European Union				United States			
	Base	Uruguay	Swiss	Uniform	Base	Uruguay	Swiss	Uniform
0.3* $\sigma_j$	26.0	17.4	9.3	16.6	3.1	2.1	1.8	2.1
1.3* $\sigma_j$	36.5	29.0	14.9	28.0	3.6	2.6	2.0	2.5
2* $\sigma_j$	45.5	36.5	17.3	35.4	4.3	3.1	2.3	3.1
3* $\sigma_j$	59.8	47.0	18.9	45.5	6.2	4.9	3.2	5.0

Source: Bureau and Salvatici (2001).

The comparison with Tables 3.3 and 3.4 shows that even though the ranking among different scenarios remains the same for the various elasticity assumptions, the MTRI is obviously quite sensitive to the assumed degree of substitution between products. Since the large values of the index are more sensitive to the assumption on substitution, the results are more affected by changes in  $\sigma_j$  in the EU than in the US, where the agricultural sector is less protected.

<sup>23</sup> Although our results confirm that the TRI is robust to changes in the elasticities, there is some evidence that the index is far more sensitive to changes in model specification (O'Rourke, 1997).

<sup>24</sup> In the case of the MTRI, we assume that only the slope of the demand functions remains constant over the period, since the other assumption (import demand elasticities remain constant) would lead to the same weights in computing the 1995 and 2000 values for the MTRI.

## **4 - MEASURES OF INTERNAL SUPPORT**

### **The decoupling issue**

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#### **4.1. Introduction**

In the Uruguay Round Agreement on Agriculture (URAA), internal support measures which are considered as decoupled are eligible for the so-called "green box" and accordingly excluded from the Aggregate Measure of Support (AMS) calculation, so from the commitments to reduce domestic support. As a result of the Blair House compromise between the European Union (EU) and the United States (US), the 1992 CAP compensatory payments and the 1990 FACT Act deficiency payments, although not decoupled in the sense of the green box definition, fell in the so-called "blue box" and accordingly were not included in the AMS.

The Seattle ministerial conference held at the very beginning of December 1999 marked the opening of the new round (the so-called Millenium Round) of multilateral trade negotiations under the World Trade Organisation (WTO). From the US perspective, the blue box exemption is now redundant since the Production Flexibility Contract (PFC) payments of the US 1996 FAIR Act may be considered as a green box measure. The Agenda 2000 CAP reform adopted in March 1999 basically extends the 1992 reform and introduces more decoupling in the system of compensatory payments to COP (cereals, oilseeds and protein crops) producers. However, the new regime of compensatory payments adopted for arable crops, beef and milk producers does clearly not comply with the requirements (as defined in Annex 2 of the URAA) for being included in the green box (see e.g., Guyomard et al., 1999; Swinbank, 1999).

Hence, during the Millenium Round, it is likely that the blue box issue will be put on the table and the privileged status of the CAP compensatory payments challenged. Furthermore, it is also likely that the Cairns Group and the US will push for increased scrutiny of policy measures currently included in the green box and so exempted from international discipline.

The proposals, containing the starting positions of member countries for the negotiations, submitted to the WTO during the first phase of the Millenium Round, confirm these expectations (WTO, 2001). Regarding the green box, unsurprisingly, some countries push for increased scrutiny of measures currently included, arguing that some of them, in certain circumstances, could have an influence on

production and prices. Others think that the green box should not be changed because it is already satisfactory. The last ones argue for a broadening of the green box to cover additional types of measures. Finally, as expected, some countries want the blue box to be scrapped because it involves payments that are only partly decoupled from production. While other countries oppose scrapping it completely and maintain that the blue box is an important tool for supporting and reforming agriculture and for achieving certain "non-trade" objectives.

To this regard, the multifunctionality issue appears as a rising concern within member countries proposals and their respective position regarding the way to deal with this issue directly relates to their positions relative to the green box issue. More specifically, although there is still considerable confusion within WTO member countries about what is really meant by the term multifunctionality, all countries agree that agricultural production provides food and non-food outputs. Some non-food outputs are not valued by market transactions and hence can be under produced relative to what society may desire. Multifunctionality proponents claim then that production-linked payments are necessary to obtain socially desired non-food benefits because of jointness relationships between agricultural production and non-food benefits. They argue that countries should have more flexibility in the domestic policy design relative to what is currently provided by the provisions of the URAA. Hence, multifunctionality proponents belong to the group of countries supporting the broadening of the green box. On the other hand, multifunctionality opponents argue that the green box provides sufficient flexibility to address non-food benefits, i.e., non-trade concerns, with the least distortions on trade. For these countries, mainly the US and the Cairns Group, multifunctionality is not a sufficient basis for continuing to pursue production-linked policies, i.e., trade distorting policies according to the URAA classification of support policies. In their view, non-food benefits are better addressed through specific instruments directly linked to public goods and/or positive externalities.<sup>25</sup>

The objective of this chapter is to contribute to the debate on decoupling and multifunctionality issues, in relation with the current URAA green box definition. More specifically, two main questions are addressed.

First, are the decoupling criteria of the green box well-designed? We focus on the green box specific criteria for decoupled income support as defined in point 6 of Annex 2 of the URAA. Our purpose is to examine whether these criteria do ensure i) that a domestic income support policy instrument complying with these criteria is decoupled, that is has actually "no effect, or at most minimal, trade distortion effects or effects on production"; ii) that a domestic income support policy instrument which

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<sup>25</sup> For a more complete discussion on this opposition, see Lankoski and Miettinen (2000). See also Paarlberg et al. (2000).

does not comply with one or more of these criteria is less decoupled than an instrument in full compliance with all criteria.

Second, what are the relative merits of various traditional income support policy instruments as regards to the promotion of multifunctionality? Our purpose is to classify alternative income support policy instruments according to their ability in achieving traditional goals of agricultural policies and to their induced trade distortion effects.

We address both these questions by developing two different analytical frameworks allowing to analyse the effects of policy instruments on production and trade. The first model puts emphasis on the key role of factor mobility assumptions as regards to the effects of alternative income support policy instruments on production (i.e., their degree of decoupling). The main feature of this model lies in the fact that it involves two agricultural sectors competing for land, which is considered as a fixed but allocatable factor, and which is alternatively assumed to be homogeneous and perfectly mobile or heterogeneous and imperfectly mobile between sectors.

The second model puts emphasis on the key role of adjustments in the number of farmers and on the land market as regards to the effects of alternative income support policy instruments on production and trade. The main features of this second model are: an endogenous price of land and an entry/exit condition that makes the number of farmers endogenous.

Both models are used to deal with the first above-mentioned question relating to the decoupling and the green box criteria issues. The second question dealing with the multifunctionality issue is addressed using the second model, where target variables relating to traditional goals of agricultural policies are defined and considered within the comparative static analysis.

This chapter is organised as follows. Section 1 provides a thorough review of literature on decoupling. Section 2 relies on the first above-described theoretical framework. It aims to examine the consistency of the specific decoupling criteria of point 6 of Annex 2 of the URAA, putting emphasis on the key role of factor mobility assumptions. In section 3, the second above-described theoretical model is used to analyse the production and trade effects of alternative income support instruments that comply more or less with the specific criteria of point 6 of Annex 2. It aims to show that, when the impact of instruments on both the price of land and the number of farmers is taken into account, policy instruments that do not comply with some of these criteria may nevertheless have minimal trade distortion effects, and/or even lower trade distortion effects than instruments in better compliance with these criteria. Section 4 deals with the multifunctionality issue and aims to analyse the relative merits of traditional income support policy instruments as regards to the promotion of multifunctionality. Using the model of section 3, the analysis of the effects of instruments on an equal cost/support basis

allows to classify these instruments according to their ability to achieve various goals traditionally assigned to agricultural policies, and according to their induced trade distortion effects.

#### **4.2. Decoupling agricultural income support: Economic issues**

From an economic point of view, the principle of decoupling internal support measures directly relates to the three basic theorems of the general theory of welfare economics:

i) In a first-best economy where no distortion does exist, free market forces lead to an efficient allocation of resources, so that a Pareto (or first-best or social) optimum is achieved within the economy. This first theorem originated the free market and trade recommendations that international organisations such as OECD (Organisation of Economic Cooperation and development) strongly advocate. It is also at the basis of the world trade liberalisation process the WTO has been promoting for several decades.

It is well-admitted however that free market forces may result in a domestic income distribution, which is "unfair". As, in virtually all economies, social equity is a major concern for governments, these latter may desire to modify the domestic income distribution once the free market equilibrium is established. It is shown in that case that the first-best optimum resulting from the free market forces may be preserved, though the domestic income distribution is changed, provided that this change is achieved through lump-sum transfers. By definition, lump-sum transfers allow to redistribute income between economic groups in order to achieve a socially desired distribution, without affecting previously obtained market equilibria. Hence, a lump-sum transfer, which is by definition the typical example of a fully decoupled instrument, is the most efficient instrument for addressing this distributional problem.

ii) In a second best economy, where distortions do actually exist, free market forces may lead to a resource allocation, which is not socially efficient. In that case, the private optimum deviates from the social one and policy intervention is required in order to restore the social optimum within the economy. This second theorem constitutes the main justification for policy intervention in domestic sectors or economies.

iii) When policy intervention is required to correct one distortion in order to restore the social optimum within the economy, the most efficient instrument is the one, which directly addresses the source of the distortion. This third argument, from which the targeting rule is derived, is the most specifically related to the principle of decoupling.<sup>26</sup>

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<sup>26</sup> The targeting rule stipulates that the best response to distortions is to use as much instruments as existing distortions to be corrected, each of these instruments tackling the consequences of the corresponding distortion in the most direct way possible (Bhagwati, 1971).

The increasing importance devoted to the notion of decoupling in the current debate regarding future agricultural policy design<sup>27</sup> clearly follows from the application of the three above basic theorems of the general theory of welfare economics to domestic agricultural sectors. More specifically, if the main objective of agricultural policies is to ensure a fair level of income to farmers relative to other domestic economic groups, then the most efficient instrument is a lump-sum transfer from the latter to the former, i.e., a transfer as decoupled as possible from agricultural production and market conditions.

The objective of this section is, on the basis of existing literature, to shed some light on the main limits of this notion of decoupling, issued from the theory of welfare economics, when it is applied to domestic agricultural sectors and policies. These limits mainly rely on practical concerns and on efficiency concerns. On the practical side, it is now well-recognised that, in practice, and at least as far as agricultural production is concerned, fully decoupled policy instruments do not exist since it is virtually impossible to break the link between income support to farmers and their production decisions. This is a key issue as regards to the definition of decoupling as well as to the measurement of the degree of decoupling of various policy instruments. On the other hand, the economic efficiency of lump-sum transfers totally relies on the first-best economy assumption. Such an assumption does clearly not correspond to the reality of agricultural markets, and more generally of contemporary economies. Thus, one may raise the question of the validity of the efficiency argument as a justification for decoupling agricultural income support instruments when concerned domestic economies remain far removed from the theoretic first-best economy. In the same vein, the economic efficiency of lump-sum transfers is ensured only for distributional purpose. If supporting farmers income is a major objective of agricultural policies, particularly in developed countries, one may not be unaware of the many other objectives (such as environment goods provision, landscape preservation, rural employment and development, food quality, etc), which are usually assigned to agricultural policies. Hence, lump-sum transfers or, more generally, highly decoupled policy instruments are not necessarily the most efficient measures for achieving these other objectives. This point is closely related to the multifunctionality issue.

#### ***4.2.1. The efficiency argument for decoupling agricultural income support: A graphical illustration***

Figure 4.1 below depicts the domestic market of an agricultural product. Curves denoted *O* and *D* figure respectively the domestic supply and demand of this product. Without loss of generality, we

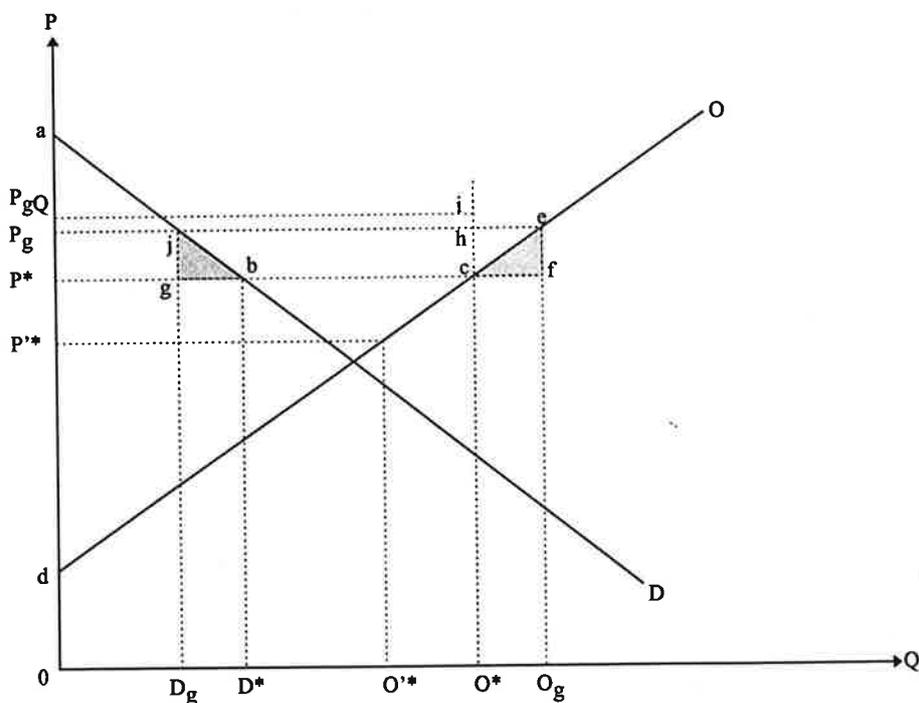
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<sup>27</sup> As well as during the Uruguay Round negotiations, which finally gave a concrete expression to this notion of decoupling through the definition of the "green box" measures included in the URAA. The green box measures are those measures, which result in no, or at most, minimal trade distortion effects or effects on production (point 1 in Annex 2 of the URAA). Hence, because they are considered as decoupled from production and market conditions, they are exempted from reduction commitment.

assume that the considered country is a small country so that the world price of the product  $p^*$  is fixed and exogenous on the home market.

In the free trade situation, the domestic market equilibrium price equals the world market price  $p^*$ . Hence, the domestic supply corresponds to  $O^*$ , the domestic demand to  $D^*$ , while the excess supply  $O^* - D^*$  is exported on the world market. Thus, at free trade equilibrium, domestic consumers' surplus is area  $abp^*$  and surplus of domestic producers corresponds to area  $p^*cd$ . Let suppose now that such a surplus distribution is considered as unfair for domestic producers within the home country. Then, policy intervention is required in order to increase domestic producers' surplus. Obviously, many policy instruments, from the most coupled (such as a guaranteed market price) to the most decoupled (such as a lump-sum transfer to producers) may be used for achieving this increase in domestic producers' surplus. In the following, we show that, in our adopted simplified framework, increasingly decoupled instruments are increasingly efficient in transferring surplus to producers, in the sense that for a given amount of transfer they induce a decreasing welfare cost for the home country.

**Figure 4.1. The market and welfare effects of three different producers' income support instruments: the guaranteed market price, the production subsidy and the production quota-subsidy**



#### 4.2.1.1. The guaranteed market price: Coupling and induced market distortions

Let suppose that in order to increase the domestic producers' surplus, the home government chooses the guaranteed market price policy instrument at level  $p_g$  on Figure 4.1. In that case, the new domestic market price  $p_g$  is higher than the world market price  $p^*$ . Therefore, the domestic supply increases from  $O^*$  to  $O_g$  while the domestic demand decreases from  $D^*$  to  $D_g$ , resulting in an increase in the home excess supply from  $O^* - D^*$  to  $O_g - D_g$ . A variable export subsidy is then needed for the price competitiveness of the domestic product to be restored, and the home excess supply to be exported on the world market.

Thus, Figure 4.1 clearly shows that the guaranteed market price instrument may be considered as fully coupled to production and market conditions since it affects simultaneously supply, demand and so trade quantities, while insulating the home market from world market signals.<sup>28</sup>

Following the guaranteed market price implementation, the surplus of domestic producers increases from area  $p^*cd$  to area  $p_ged$ , thanks to a transfer from domestic consumers who now pay a higher price for the product and from domestic taxpayers who bear the export subsidy expenditures. Then, the domestic consumers' surplus decreases from area  $abp^*$  to area  $ajp_g$ , while the cost of export subsidies for taxpayers is represented by area  $jefg$ . One easily verifies that the surplus gain for producers is lower than the sum of the consumers' surplus loss and the export subsidy budget expenditures. In other word, following the guaranteed market price implementation a share of the induced transfer from both consumers and taxpayers to producers is lost for the overall home country. This net welfare loss is measured on Figure 4.1 by areas  $jbg$  and  $cef$ . Both areas correspond to the welfare cost of the two distortions (one on the supply side and one on the demand side) generated by the guaranteed market price policy.

#### 4.2.1.2. The production subsidy: Coupled to production only and less market distorting

On Figure 4.1, the production subsidy shifting the domestic producer price from  $p^*$  to  $p_g$  allows to ensure home producers the same level of surplus than the previous guaranteed market price. The main difference between both instruments is that with the production subsidy, the domestic market price remains at the world price level  $p^*$ . It results that the production subsidy instrument does not affect

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<sup>28</sup> One may underline that the domestic market can remain sensitive to world market signals if the export subsidy is fixed, i.e., if the guaranteed market price is ensured through a fixed production subsidy and a fixed consumption tax, both implemented at the same level.

the home consumption of the product relative to the free trade situation. In addition, the excess supply (i.e.,  $O_g - D^*$ ) may now be exported without the aid of an export subsidy.

Thus, Figure 4.1 shows that, in our simplified framework, the production subsidy may be considered as less coupled than the guaranteed market price. In fact, both instruments induce the same effect on the domestic supply quantity, but the production subsidy leaves the demand quantity unchanged relative to the free trade situation. Therefore, the total effect on trade is lower with the production subsidy than with the guaranteed market price. In addition, the production subsidy does not entirely insulate the home market from world market signals since domestic demand and, in turn, trade remain sensitive to world market price fluctuations.<sup>29</sup>

Finally, the production subsidy leaves the domestic consumers' surplus unchanged with respect to the free trade situation (i.e., area  $abp^*$ ). Domestic producers benefit from the same surplus level than in the previous guaranteed market price regime (i.e., area  $p_ged$ ). While budget expenditures for the production subsidy, as measured by area  $p_gefp^*$ , are borne by taxpayers. Then, Figure 4.1 shows that with the production subsidy instrument the surplus transfer to domestic producers is entirely borne by domestic taxpayers.

With respect to the free trade situation, the production subsidy induces a net welfare loss equals to area  $cef$ . This loss corresponds to the welfare cost of the distortion induced by the production subsidy on the supply side. Therefore, the production subsidy is less distorting than the guaranteed market price since it induces no distortion on the demand side. Hence, the production subsidy is more efficient than the guaranteed market price in transferring surplus to domestic producers since for the same amount of transfer, it implies a lower welfare loss for the home country.

One may emphasise that the previous analysis of the impact of both the guaranteed market price and the production subsidy legitimates the two basic criteria adopted in the URAA definition of the "green-box" measures. Firstly, it has been shown that the production subsidy induces no distortion on the demand side. Then, this result legitimates the basic criteria (ii) of point 1 in Annex 2 of the URAA: "the support in question shall be provided through a publicly-funded government programme...not involving transfers from consumers". Secondly, we have shown that the production subsidy and the guaranteed market price both generate a domestic distortion on the supply side because they provide producers a price support leading them to increase their supply quantity. This second result legitimates

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<sup>29</sup> Once again, it can be noted that the domestic supply may also remain sensitive to the world market signals if the production subsidy is fixed.

the first basic criteria (i) of point 1 in Annex 2 of the URAA: "the support in question shall not have the effect of providing price support to producers".

#### 4.2.1.3. *The production quota-subsidy: A decoupled instrument?*

Starting from the previous production subsidy situation, one sees on Figure 4.1 that constraining domestic producers to continue to produce  $O^*$  instead of expanding their production level to  $O_g$  would prevent the distortion on the supply side to be generated. One way to break the link between the price support provided to domestic producers by the production subsidy and the output supply level would be to implement a production quota, fixed at level  $O^*$ . In that case, however, the production subsidy should be increased with respect to the previous situation, in order to ensure domestic producers the same level of surplus.

On Figure 4.1, when the domestic production is fixed at  $O^*$  through a production quota, the unit production subsidy  $p_{gQ} - p^*$  implies a level of producers' surplus (i.e., area  $p_{gQ}icd$ ) equal to the one previously obtained with the guaranteed market price or with the unit production subsidy  $p_g - p^*$  (i.e., area  $p_ged$ ). On the other hand, with the production quota-subsidy instrument, the domestic market price still remains at the world market price level  $p^*$ . Hence, the domestic demand is still unchanged at its free trade level  $D^*$ , while the excess supply  $O^* - D^*$  may be exported without any export subsidy.

Therefore, it is clear from Figure 4.1 that such a production quota-subsidy instrument may be considered as decoupled since it does not affect the product market equilibrium relative to its free trade situation. It results that the production quota-subsidy instrument allows to transfer surplus to domestic producers without generating any distortion. In fact, the production quota prevents the output supply to expand due to the production subsidy incentive, so that no distortion is created on the supply side. Finally, one sees that the production quota-subsidy is efficient in transferring surplus to producers since it allows to ensure them a certain level of surplus without creating any distortion, i.e., with no welfare cost for the home country.

One may emphasise that, at least at the sectoral level, when the quota is fixed at the free trade output quantity level, the production quota-subsidy instrument is very similar to a fixed lump-sum transfer. Starting from the free trade situation, the production quota-subsidy may be assimilated to a fixed unit payment  $p_{gQ} - p^*$  applied to a fixed eligible output quantity  $O^*$  corresponding to a historical volume

of production.<sup>30</sup> In other words, such a production quota-subsidy allows to duplicate the effects of a lump-sum transfer policy, the subsidy acting to transfer surplus to producers without generating a distortion on the demand side, while the quota fixed at the free trade output level ensures that no distortion results on the supply side.

However, it is important to note here that the production quota-subsidy instrument, such as represented on Figure 4.1, is decoupled and efficient only in our simplified framework, i.e., in a short-term, static, and mono-product partial equilibrium with no risk.

It is very easy to see on Figure 4.1 that the production quota-subsidy instrument turns to be less efficient and less decoupled than previously when the analysis becomes dynamic. Let suppose for example that the world price of the product decreases from  $p^*$  to  $p^*$ . Then, the free trade output quantity decreases to  $O^*$ . Consequently, if both the production quota and the production subsidy remain applied at the same levels than previously (i.e.,  $O^*$  and  $p_{gQ} - p^*$ , respectively), then they now generate a distortion on the supply side, resulting in a welfare loss for the home country.<sup>31</sup>

Hence, at this stage, two main ideas are in order. Firstly, the production quota-subsidy instrument may be considered as decoupled and efficient for transferring surplus to producers if and only if the quota level is continuously adjusted to the changes in the free trade output quantity resulting from the changes in the corresponding world price. Obviously, this implies the unit production subsidy to be adjusted too in order to still ensure domestic producers the same final level of surplus.

Secondly, and more importantly, this suggests that criteria adopted in the definition of decoupled income support instruments (point 6 of Annex 2 of the URAA) as part of the URAA definition of the "green-box" measures do not actually ensure that these income support instruments are no production and trade distorting. More precisely, criteria (ii), (iii) and (iv) in point 6 stipulate that for income support to be considered as decoupled, "the amount of such payments in any given year shall not be related to, or based on (ii) the type or volume of production, (iii) the prices, domestic or international and (iv) the factors of production employed, in any year after the base period. The previous production quota-subsidy instrument clearly conforms to these criteria. In fact, as already mentioned, the fixed unit subsidy  $p_{gQ} - p^*$  may be considered as a unit payment calculated on historical domestic and world market prices observed during a given base period, while the quota level  $O^*$  may be analysed as

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<sup>30</sup> Such a historical volume of production may be the supply quantity observed during a given base period or may be calculated as the product of a historical yield and a historical volume of a production factor employed (such as a land base area or a livestock base number for example), observed during the same given base period.

<sup>31</sup> It is implicitly assumed here that the production quota-subsidy instrument remains constraining following the world price decrease, i.e.,  $p^* + (p_{gQ} - p^*) > p^*$ .

a fixed eligible output quantity corresponding to a historical sectoral volume of production observed on the same given base period. Then, although the production quota-subsidy instrument conforms to the criteria (ii), (iii), and (iv) of point 6, the previous analysis clearly shows that such an income support policy is however production and trade distorting when world market price fluctuations are taken into account. Furthermore, the previous analysis suggests that contrary to the requirements of criteria (ii), (iii) and (iv), the production quota-subsidy instrument would remain no production and trade distorting (i.e., decoupled) in a dynamic framework only if the quota level, i.e., the base period volume of production (or the base period yield and/or volume of factor employed) is continuously adjusted to the world market conditions observed "in any year after the base period". In the same way, it is easily shown on Figure 4.1 that when the level of the quota is adjusted to the new free trade output quantity  $O^*$ , an increase in the unit production subsidy in order to still ensure domestic producers the same final level of surplus does not induce any distortion on the domestic market. Hence such an adjustment of the unit production subsidy in response to the current decrease in the world market price, though in contradiction with criteria (iii) of point 6 is actually not market and trade distorting.

#### 4.2.1.4. *The fixed lump-sum payment: efficient and "decoupled"*<sup>32</sup>

Let suppose now that to ensure domestic producers the same level of surplus than in the previous cases, the home government adopts a system of fixed lump-sum payments based on historical criteria. Thus, on Figure 4.1, the total amount of payments given to producers corresponds to area  $p_{gQ}icp^*$ . This amount may be defined as a fixed unit payment  $p_{gQ} - p^*$ , applied to a base volume of production  $O^*$ , or equivalently to the product of a base yield and a base volume of a given production factor (this latter varying according to the chosen eligibility criteria for the fixed lump-sum payment).

Hence, in our simplified framework, the fixed lump-sum payment instrument may clearly be considered as decoupled since it does not affect the product market equilibrium relative to its free trade situation. Moreover, like the production quota-subsidy, the fixed lump-sum payment is efficient in transferring surplus to producers since it allows to ensure them a certain level of surplus without creating any distortion, i.e., with no welfare cost for the home country.

The main difference between the fixed lump-sum payment and the production quota-subsidy is that the former remains efficient and decoupled even when shifting from a static to a dynamic framework. It is easily shown on Figure 4.1 that when the world market price decreases from  $p^*$  à  $p'^*$ , the home output supply decreases from  $O^*$  to  $O'^*$ , which corresponds to the new efficient allocation of

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<sup>32</sup> Guillemets here mean that although the following analysis suggests that the fixed lump-sum payment is a fully decoupled income support instrument, such a result heavily depends on our simplified static, mono-product partial equilibrium framework with no risk. This framework does not take into account many factors contributing to reduce the degree of decoupling of the fixed lump-sum payment instrument (cf. paragraph 4.2.2).

resources on the supply side. It can be noted here that if the total amount of payments remains unchanged, the domestic producers benefit from the same transfer of surplus than previously but their final level of total surplus is reduced (from  $p_{g0}icd$  to  $(p^* + (p_{g0} - p^*))icd$ ). However, like in the case of the production quota-subsidy, the final level of producers' surplus can be maintained thanks to an increase in the total amount of payments without generating any distortion on the home market (though, once again, such an adjustment in the total amount of payments to producers contradicts criteria (ii), (iii) and/or (iv) of point 6 of Annex 2).<sup>33</sup>

Finally, the graphical analysis of this section confirms the theoretical result among which in a first-best situation, decoupling agricultural income support from production and market conditions constitutes the most efficient way to transfer income to domestic agricultural producers. In our simplified framework, the fixed lump-sum payment instrument based on historical criteria appears as a fully decoupled and efficient policy. In addition to the efficiency argument, the fixed lump-sum payment exhibits other advantages that cannot be illustrated through Figure 4.1. Firstly, when it is fixed, the lump-sum payment does not depend on domestic and world market conditions so that the total budget cost of such an income support policy is easy to foresee and monitor. This is obviously not the case with the guaranteed market price as well as with the production subsidy. Secondly, by clearly defining the criteria of eligibility for payments, a fixed lump-sum payment policy allows to better determine which economic group is the target of the income transfer. Hence, a fixed lump-sum payment may be easily targeted on domestic agricultural producers while it is well-admitted that income support provided through more coupled instruments spreads upstream and downstream from agricultural producers, and partly benefits to both the domestic agricultural input and food processing sectors. Moreover, while income support may be easily targeted on specific groups of agricultural producers (such as "small" producers or producers located in less favoured areas) through a conveniently design fixed lump-sum payment system, it is nearly impossible to select the beneficiaries of the support provided through a guaranteed market price or a production subsidy. Therefore, it is easier to achieve a fairer income distribution across domestic agricultural producers through a fixed lump-sum payment system than through more coupled instruments.

One may underline however that the real situation of agricultural markets is far more complex than the one illustrated on Figure 4.1. Even if the fixed lump-sum instrument appears as fully decoupled on this figure, it has actually, in practice, effects on the risk perception of producers, on their individual decision to stay in or to leave the agricultural sector, on markets of variable inputs and primary factors, on markets of other agricultural outputs (all agricultural input and output markets being strongly

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<sup>33</sup> It is interesting to note that the fixed lump-sum payment system based on historical criteria considered here results, in our simplified framework, in the same effects on the product market equilibrium than a Production Entitlement Guarantee (PEG) system fixed at level  $O'$ .

interrelated), etc.<sup>34</sup> In fact, all these effects potentially induce shifts in domestic supply and demand curves which are not taken into account in Figure 4.1. Obviously, when these indirect effects on domestic supply and demand, through shifts in the corresponding curves, are taken into account, the fixed lump-sum payment instrument appears as less decoupled than in the previous analysis. Of course, this conclusion applies to all other policy instruments.

#### ***4.2.2. In practice, income support policy instruments are never fully decoupled***

The previous analysis suggests that the fixed lump-sum payment based on historical criteria is fully decoupled. In particular, it is shown that such an instrument has no effects on the domestic producers' decisions. However, this result is conditioned by the simplified framework used, which strongly relies on rather restrictive assumptions. Hence, in this paragraph, we analyse more specifically the links between farmers' income and their production decisions when some of these restrictive hypotheses are relaxed. We show how even predetermined and fixed lump-sum payments do change producers' decisions so that they are not practically fully decoupled. In addition, the following analysis constitutes a first step as regards to the problem of measuring the degree of decoupling of income support policy instruments since it emphasises the main directions where further research, and particularly further quantitative assessments, are needed in order to address this question.

##### *4.2.2.1. The fixed lump-sum payment and the individual decision to stop producing: The "cross-subsidisation" effect*

When production is required in order to perceive a fixed lump-sum payment, then this policy instrument may affect the output supply of less efficient agricultural producers by providing them an incentive to stay in the home agricultural sector and continue to produce. This mechanism, which is called the "cross-subsidisation" effect, is illustrated on Figure 4.2. The curves *CTM* and *C<sub>m</sub>* denote respectively the total average cost and the total marginal cost of a specific mono-product farm.

When the domestic producer price equals  $P_0$ , then the considered farmer produces the quantity  $Q_0$  for an induced profit corresponding to area *abcd*. If the producer price decreases to  $P_1$ , then the considered producer suffers from a negative profit whatever level of production he chooses. In particular, the output level  $Q_1$  results in a negative profit measured by area *efgh* on Figure 4.2. In this case, the producer will decide to stop producing and to leave the agricultural sector.

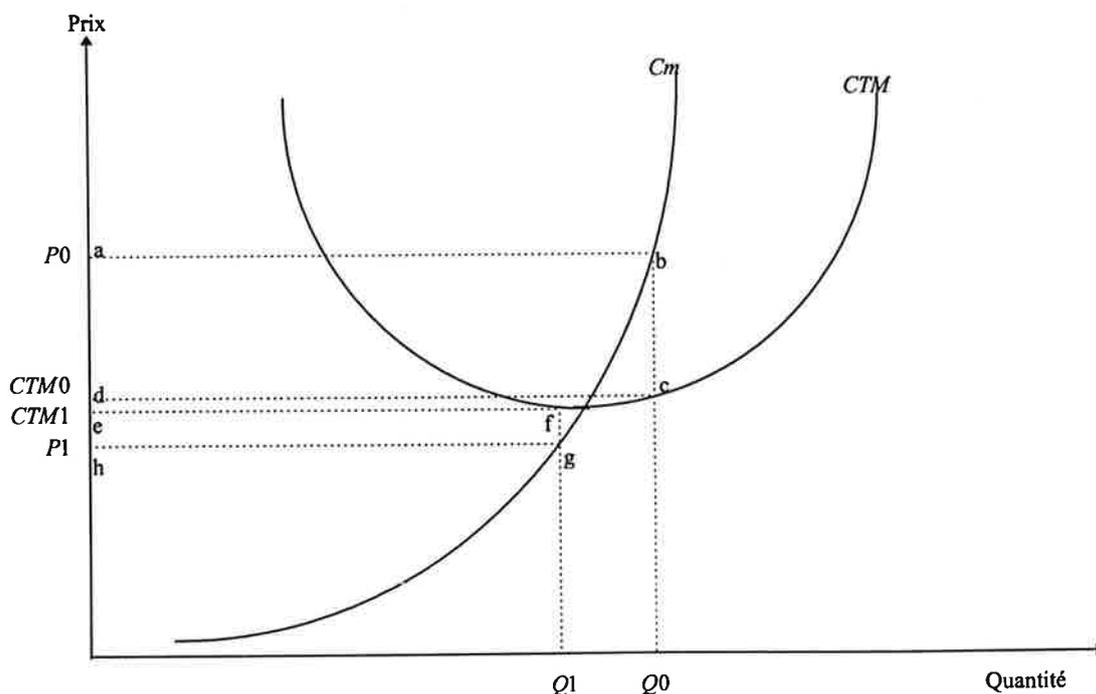
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<sup>34</sup> Obviously, these effects are different according to the definition of the historical criteria retained to calculate the fixed lump-sum payment (the basis of the payment, the definition –at the individual farm level, at the national level or at other geographical zone levels- of the base eligible output volume, or the base yield and input quantity volume, the requirement to produce or not in order to benefit from the payment, etc).

Let suppose that, still facing the price level  $P_1$ , the considered producer now perceives a fixed lump-sum payment based on historical criteria, i.e., in particular, which amount does not depend on the volume of output currently produced. If this producer is not required to produce in order to benefit from this payment, then he will stay in the agricultural sector for remaining eligible to the lump-sum payment but will continue to produce nothing. When, at reverse, production is required in order to perceive the fixed lump-sum payment, two cases may occur. If the amount of the payment remains lower than the loss induced by the production activity at level  $Q_1$  (i.e., area  $efgh$  on Figure 4.2), then the producer will decide to leave the agricultural sector. At reverse, if the amount of the payment is greater than the loss resulting from producing the quantity  $Q_1$ , then the lump-sum payment will act as an incentive for the farmer to stay in the agricultural sector still producing output level  $Q_1$ . Indeed, in that case his induced profit is positive and equal to the amount of the perceived payment less the loss resulting from the production activity. In such a case, there is "cross-subsidisation" since the fixed lump-sum payment and the related eligibility conditions lead the agricultural producer to continue to produce a positive quantity of output whereas regarding market conditions he is inefficient. Therefore, in the absence of the lump-sum payment he would have decided to stop producing and to leave the agricultural sector.

Finally it is interesting to note that the above result legitimates criteria (v) of point 6 of Annex 2 of the URAA, which stipulates that for income support to be considered as decoupled, "no production shall be required in order to receive such payments".

**Figure 4.2. The "cross-subsidisation" effect**



4.2.2.2. *The fixed lump-sum payment and labour decisions of agricultural households*

Fixed lump-sum payments may induce a change in production decisions through their indirect effects on labour decisions (derived demand of family and hired labours on farm, supply of family labour on and off farm) of agricultural households.

Let's take the case of an agricultural single household, simultaneously producer and consumer, using a production technology with fixed capital and land factors and variable labour factor. As a producer, this household chooses his output supply (i.e., what and how much to produce) and the corresponding derived demand of variable inputs. As a consumer, the considered household chooses his final demand of goods and his labour supply. Hence, as fixed lump-sum payments increase the household's income, they affect both his output choices and his output level decisions through an income effect on his labour decisions. Fixed lump-sum payments affect the household's derived demand of family and hired labour on farm as well as his family labour supply on and off farm (Benjamin and Guyomard, 1998). Such a mechanism is illustrated on Figure 4.3 in the simplified case where the considered single household does not supply his own family labour off farm.

**Figure 4.3. An illustration of the effects of a fixed lump-sum payment ( $t_f$ ) on the labour decisions of an agricultural single household (no off-farm family labour)**

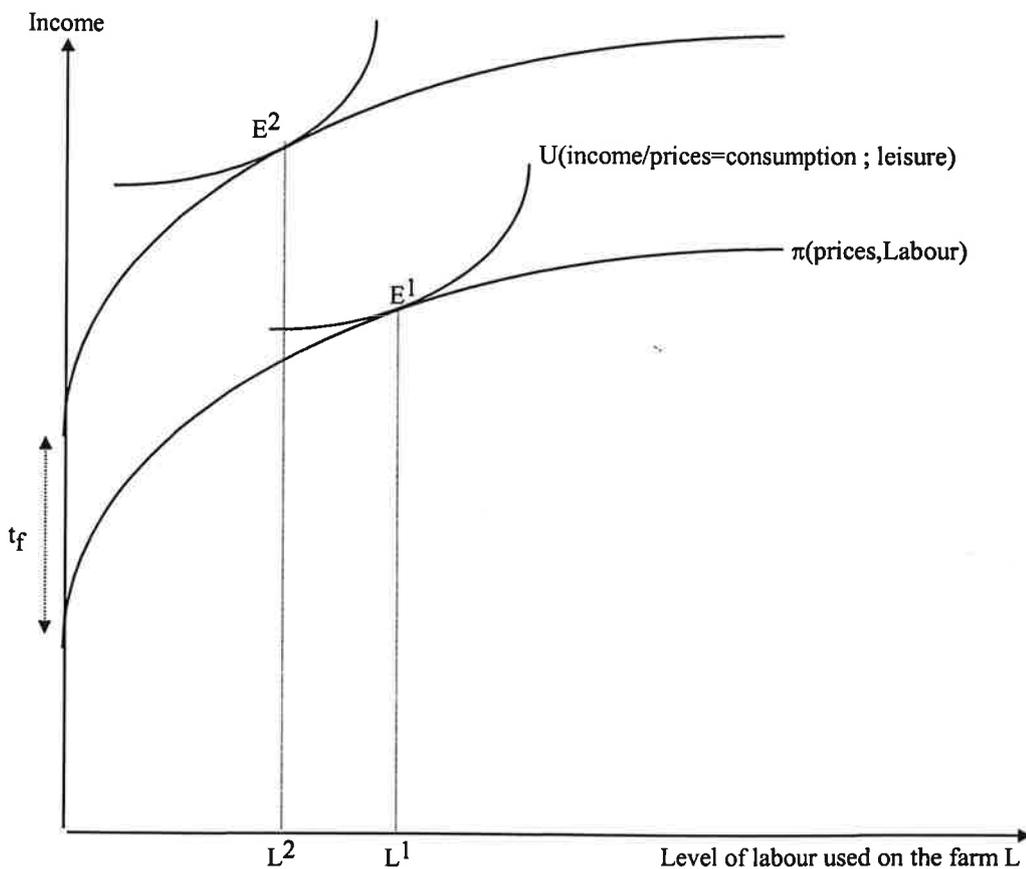


Figure 4.3 shows that starting from the initial equilibrium  $E^1$ , the considered agricultural household perceiving a fixed lump-sum payment  $t_f$  benefits from an increase in his income which makes him to adjust his labour decisions. This income effect leads to the final equilibrium  $E^2$ . Hence, with respect to the initial situation, the fixed lump-sum payment induces: i) a decrease in the quantity of labour used on farm (from  $L^1$  to  $L^2$ ) and ii) an increase in the leisure time, the total income and the utility level of the household.

#### *4.2.2.3. The fixed lump-sum payment and investment decisions*

Fixed lump-sum payments may also affect both producers' output choices and output level decisions through their potential positive effect on producers' investment decisions (we adopt now a long-term perspective and consider that capital and land factors are variables).

This positive impact of fixed lump-sum payments on agricultural investment may result from two different effects. On the one hand, fixed lump-sum payments increase farm incomes over returns from the market alone. Then, in the absence of perfect capital and information markets, a significant amount of these payments are likely to be invested in the farm (Phimister, 1995; Roberts, 1997). On the other hand, fixed lump-sum payments increase farm wealth. Hence, they may modify investment decisions by providing farmers improved credit facilities.

Finally, this potential positive impact of fixed lump-sum payments on farmers' investment is likely to facilitate farm access to improved technology, to increase farm input use and then to increase farm output supply.

#### *4.2.2.4. The fixed lump-sum payment and risk*

Due to the risk perception of agricultural producers, fixed lump-sum payments may affect output choices and output level decisions when risk is taken into account. More precisely, as fixed lump-sum payments increase farm incomes they may induce two effects related to the risk perception of producers. The first effect is an income effect, which implies a shift of the profit distribution function to a lower range of risk aversion in the producer's utility function.<sup>35</sup> The second effect is an insurance effect resulting from a reduced income variability, *ceteris paribus*. Both the income and the insurance effects contribute to increase agricultural output supply and input utilisation relative to a situation where fixed lump-sum payments would not exist (Hennessy, 1998).

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<sup>35</sup> Assuming, as it is well-admitted, a decreasing absolute risk aversion.

#### *4.2.2.5. The question of the measurement of the degree of decoupling of income support policy instruments*

Predetermined fixed lump-sum payments may affect output choices and output level decisions of farmers, so that they cannot be considered as fully decoupled, because: i) they modify labour decisions of agricultural households, ii) they influence farmers' investment decisions and iii) they reduced risks facing agricultural producers.

Obviously, these three effects may also be observed when income support is provided through more coupled policy instruments. Hence, the main question at stake is the one of the magnitude of these three effects when income support to agricultural producers is provided through fixed lump-sum payments relative to more coupled policy instruments. Of course it is difficult to answer this question on a general ground and it is likely that only pieces of answers, on a case by case and empirical basis, can be provided.

There are few analysis, and moreover of available quantitative assessments, of the effects of direct payments to agricultural producers on their output choices and output level decisions. For French cereal farms (with risk excluded from the analysis), Benjamin and Guyomard (1998) show that the CAP 1992 compensatory payments have little effects on the probability of off-farm labour participation of agricultural households' wives. A study of acreage responses in the US by Chavas and Holt (1990) finds that elasticities of area planted in soybean and corn with respect to farm incomes are more than half those relative to the own output prices (for example, their estimated elasticity of corn area is nearly 0.10 with respect to income and nearly 0.30 with respect to corn price). Hennessy (1998) examines the impact of the US 1990 deficiency payments for a 400 acres Iowa farm specialised in corn mono-production. His analysis takes into account risk faced by the producer and distinguishes, within the total impact of the US deficiency payments on nitrogen fertiliser use and on yield, the effects related to risk (i.e., the above-mentioned income and insurance effects) from the coupling effect. Hennessy shows that, among the effects related to risk, the estimated income effect on nitrogen fertiliser use and on yield remains very low while the estimated insurance effect on these two variables is substantial and markedly greater than the coupling effect. With respect to a free market situation, the considered US deficiency payments make the nitrogen fertiliser use and the obtained yield to increase by respectively 17% and 3.1 %, the coupling effect explaining only 10 to 20% (according to various assumptions on the level of policy variables and on the producer's preferences) of these changes.

It is difficult to conclude definitely from these few studies, but one may however emphasise that even supposedly decoupled income support instruments may have substantial effects on output choices and output level decisions of agricultural producers.

#### ***4.2.3. Decoupling income support policy instruments: The limits of the efficiency argument in a second-best world***

The efficiency argument for decoupling agricultural income support instruments is established only under the first-best assumption, i.e., when no distortion do actually exist within the considered economy. In practice however, in all economies, market and policy distortions do exist. Hence, real agricultural markets and sectors remain far removed from the theoretic first-best situation. Therefore, in this paragraph, we show how the efficiency argument for decoupling agricultural income support may be questioned when the rather restrictive first-best assumption is relaxed.

##### ***4.2.3.1. The fixed lump-sum payment and the marginal cost of taxation***

In the previous paragraphs, it is implicitly assumed that the total amount of lump-sum payments granted to domestic agricultural producers equals the total amount of tax levied on domestic taxpayers. In other words, it is assumed that the opportunity cost of public funds (or the marginal cost of taxation) equals zero.

In practice, the opportunity cost of public funds is most often different from zero, i.e., one monetary unit levied on taxpayers allows less than one monetary unit paid to agricultural producers. It is clear that in all economies, the income distribution problem addressed by national governments goes far beyond the only objective of supporting agricultural producers. In fact, governments intervene in order to redistribute national income across all domestic economic agents and activities, i.e., the various production sectors, the various types of consumers and the various types of taxpayers. To this regard, a share of the national income must be levied on specific groups to be redistributed to other groups. Operated levies do not induce distortions, nor national net welfare loss, only when they result from lump-sum taxation. In practice, lump-sum taxation implementation is impossible since it requires governments to know perfectly all the characteristics of all economic agents. Hence, practically, indirect taxation systems, based on, for example, consumption of the various goods, wages, individual income, etc are always used. As, such indirect tax instruments affect individual behaviours, they induce distortions and lead to a net welfare loss (i.e., the loss of surplus of levied agents exceeds the gain of surplus of agents benefiting from the income redistribution) for home economies. In other words, used taxation systems are distorting and the marginal cost of taxation is usually different from zero.

Several studies provide empirical estimates of the marginal cost of taxation for various countries. Their results vary substantially and suggest that the marginal cost of taxation ranges (according to the country, the time period and adopted hypotheses) from few percents to more than 50% of each levied monetary unit. Findlay and Jones (1982) find that in 1978-79, the marginal cost of taxation in Australia ranged from 0.1 to 0.56 cents of each levied Australian dollar, their favourite estimate being

0.4. Ballard et al. (1985) show that in 1973, the US opportunity cost of public funds ranged from 0.17 to 0.56. Browning (1987) estimates that in 1984, the US marginal cost of taxation lied between 0.32 to 0.47.

Thus, all these studies indicate that the marginal cost of taxation in the various countries is likely to be different from zero. In this case, the efficiency of the fixed lump-sum payment for supporting agricultural income is questioned. In fact, the higher the marginal cost of taxation, the greater the national welfare loss induced by lump-sum payments, or more generally, decoupled policy instruments, *ceteris paribus*. This raises the question of the relative efficiency of more coupled policy instruments in economies characterised by high marginal costs of taxation. The Moschini and Sckokai (1994) answer to this question is mitigated. In fact, they show analytically that when the home's government objective is to ensure a minimum level of income to domestic producers in presence of a positive marginal cost of taxation, the fixed lump-sum payment to producers always belongs to the optimal policy instrument package. More specifically, they show that the optimal policy is a lump-sum payment to producers, associated with two more coupled instruments: an export tax in order to improve the terms of trade of the home country and a consumption tax in order to correct the distortion induced by the marginal cost of taxation.

#### *4.2.3.2. The fixed lump-sum payment and externalities*

Agricultural production is a well-known source of negative and positive externalities. In other words, market distortions do actually exist on agricultural markets. Such distortions are not taken into account in previous paragraphs, so that the free trade equilibrium constitutes the most efficient equilibrium for the considered home country. Consequently, the fixed lump-sum payment, which as a decoupled instrument does not change the initial free trade market equilibrium, appears as the most efficient instrument for supporting domestic producers' income. However, it is a well-known result that when market distortions do exist, the free trade equilibrium is no longer efficient for the home country. Specifically, in presence of negative and positive externalities related to the domestic agricultural production, the free trade market forces lead to an "over-production" of negative externalities and an "under-production" of positive externalities, relative to the social optimal corresponding quantities.

Thus, starting from such an initial situation, if the home government's concern is still to transfer a certain level of surplus to domestic agricultural producers, is the predetermined, fixed lump-sum payment the most efficient policy instrument? More generally, is the decoupling of agricultural income support instruments justified, in welfare terms, when the national agricultural policy seeks simultaneously various objectives?

In the following, we show that more coupled instruments may be more efficient than fixed lump-sum payments for transferring surplus to agricultural producers when the domestic agricultural production generates positive externalities (such as landscape preservation or rural employment and development, for example). Figure 4.4 below illustrates this point. An important hypothesis in Figure 4.4 is that the generation of positive externalities increases with the production volume of the considered agricultural output (i.e., the agricultural output and the positive externalities are joint in production).

In Figure 4.4, the supply curve resulting from the domestic producers' optimisation programme, i.e., the aggregate private marginal cost curve, is denoted  $O$ . The aggregate public marginal cost curve is denoted  $OP$ . This curve corresponds to the output supply curve, which would be observed if domestic producers were paid for the positive externalities they produce in conjunction with their output supply quantity. In the free trade market situation, for a world market price  $p^*$ , the home net welfare loss due to the positive externality distortion corresponds to area  $c\beta\xi$ . The domestic supply is  $O^*$ , whereas the required social optimal quantity is  $OP^*$ . Hence, the free trade market equilibrium is not optimal from the social point of view since it leads to an under-provision of positive externalities.

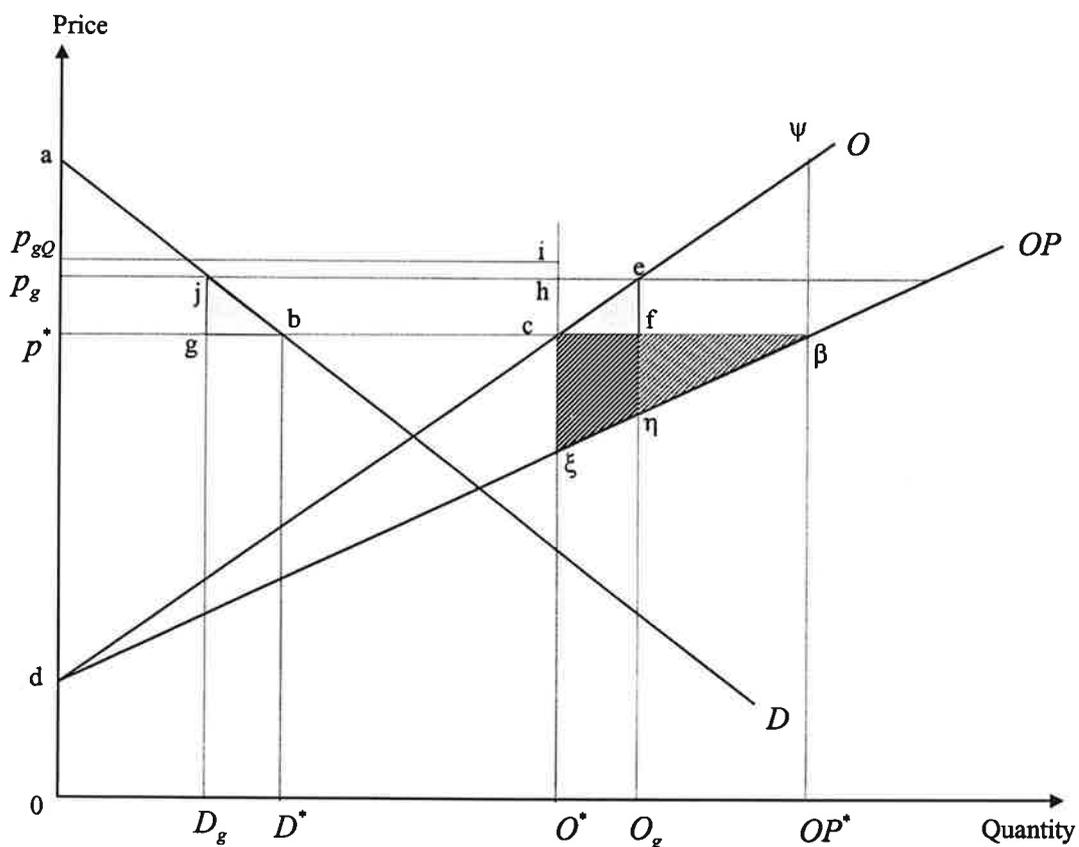
Starting from this situation let suppose that the home government decides to support domestic producers' income through a guaranteed market price  $p_g$ . Then, domestic output supply increases to  $O_g$ . As already mentioned, the guaranteed market price induces a welfare loss on the supply side (triangle  $cef$ ) and a welfare loss on the demand side (triangle  $jb g$ ). However, Figure 4.4 shows that following the guaranteed market price implementation the under-provision of positive externalities is reduced with respect to the initial situation, so that the related welfare loss is now limited to area  $f\beta\eta$ . Therefore, the guaranteed market price may lead to a net welfare gain for the home country if the gain resulting from the correction of the positive externality distortion (i.e., area  $cf\eta\xi$ ) is greater than the welfare loss due to the price support instrument (i.e., areas  $cef$  and  $jb g$ ). If this is actually the case, thus the coupled guaranteed market price instrument is more efficient than the decoupled fixed lump-sum payment (ensuring domestic producers the same transfer of surplus than the guaranteed market price, i.e., corresponding to area  $p_g q icp^*$ ), which does not change the situation of the home country in terms of welfare relative to the initial situation.<sup>36</sup>

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<sup>36</sup> It is important to note that the production subsidy instrument is still more efficient than the guaranteed market price since for an equivalent surplus transfer to producers, it does not generate a welfare loss on the demand side.

Such a result indicates that in a second-best world, coupled policy instruments may reveal more efficient than decoupled measures.<sup>37</sup>

**Figure 4.4. The relative efficiency of the coupled guaranteed market price and the decoupled fixed lump-sum payment when output production generates positive externalities**



#### 4.2.3.3. Decoupling agricultural income support instruments in a multi-output, multi-instrument framework

In most developed countries, numerous policy instruments are in force on agricultural markets. Hence, it is rather uncommon that for national governments, the initial situation for policy intervention corresponds to the free trade market equilibrium. Moreover, in a lot of developed countries, support to agricultural producers is still partly provided through coupled policy instruments. And most often decoupled internal support instruments are implemented in order to replace previous more coupled instruments.

<sup>37</sup> One may underline that this result is contingent to the assumption of jointness relationships between the agricultural output and the positive externalities that we adopted in our analysis.

In the following, we show that, in a multi-output framework where price support instruments are initially in force on considered markets, the replacement of some of these coupled instruments by "decoupled" direct payments does not necessarily allow to correct previously existing production and trade distortions. It can even be shown that in some cases, those existing distortions are aggravated following such a partial decoupling process.

For simplifying the presentation, we suppose that the considered country produces only two homogeneous agricultural products, a vegetal product and an animal product, on a fixed land area  $\bar{L}$ . Let suppose first that a coupled policy instrument, such as a guaranteed market price or a production subsidy, is implemented in order to support the domestic vegetal producers' income. In such a case, policy intervention in the vegetal sector induces, *ceteris paribus*, an increase in the domestic crop supply and an increase in both the variable input use and the volume of primary factors employed in the vegetal sector. Regarding the land factor, as the domestic total land area is fixed, the policy intervention implies a change in the acreage allocation, favouring the vegetal sector to the detriment of the animal sector. Let suppose now that the previous coupled instrument is replaced by a fixed lump-sum payment. At least three effects will contribute for this decoupling process does not allow to remove previous production and trade distortions resulting from the coupled instrument.

Firstly, due to the fact that the income support in the vegetal sector was previously provided through a coupled policy instrument, a time delay is needed for the domestic vegetal output supply to adjust on its free trade level. Particularly the stock of stockpiled capital, resulting from past investment decisions driven by the previous coupled policy instrument, will continue to partly determine the vegetal output volume produced on during a certain time period. In fact, it has been shown (Johnson and Pasour, 1981) that the lower the depreciation rate of capital, the longer the time delay for the output supply to adjust down (*ceteris paribus*).

Secondly, taking into account risk, the risk diversification effect according to the so-called portfolio choice model is likely to appear. Clearly, fixed lump-sum payments granted to vegetal producers may, *ceteris paribus*, reduce the variability of profits resulting from the vegetal production. Therefore, it is very likely that the decoupling process in the vegetal sector will not allow to restore the free trade market equilibrium, the vegetal sector being still favoured to the detriment of the animal sector in the final situation.

Thirdly, a more general effect, related to the coexistence of various support policy instruments in force in the different agricultural sectors, must also be emphasised. Such an effect is illustrated on Figure 4.5. The free trade equilibrium corresponds to point  $E$  where the marginal return to land used in vegetal production equals the marginal return to land used in animal production. Then, at point  $E$ , the acreage allocated to the vegetal sector is  $LVE'=VE'$  while the acreage devoted to the animal sector is

$LAE'=AE'$ . Let suppose now that the national government chooses to support producers' income in both sectors through direct payments per hectare,  $scv$  for the vegetal sector and  $sca$  for the animal sector. For simplification purpose, we assume in Figure 4.5 that these direct payments per hectare induce no distortion in acreage allocation.<sup>38</sup> Hence, the new equilibrium situation corresponds to point  $F$  located just above point  $E$ .

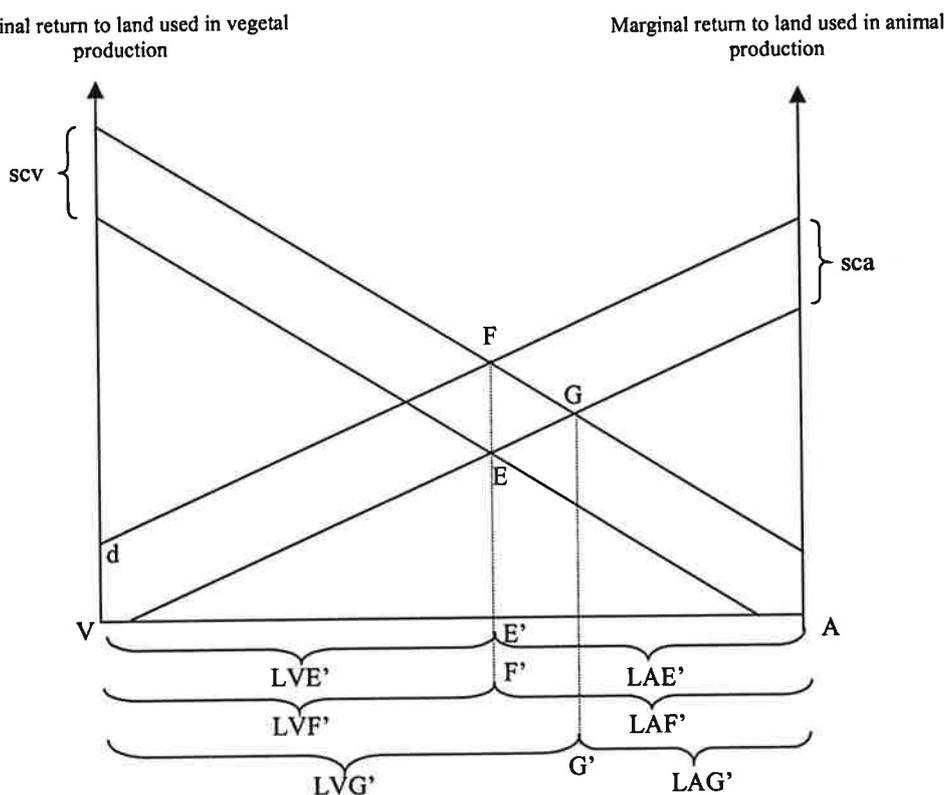
Starting from the  $F$  equilibrium, we assume that the national government replaces the direct payment per hectare by a fixed lump-sum transfer in the animal sector. Hence, the new acreage allocation equilibrium corresponds to point  $G$  on Figure 4.5. Consequently, the decoupling process in the animal sector induces an increase in the vegetal sector acreage (from  $LVF'=VF'=VE'$  to  $LVG'=VG'$ ) and a decrease in the animal sector acreage (from  $LAF'=AF'=AE'$  to  $LAG'=AG'$ ). Thus, it is easily shown that the final equilibrium  $G$  corresponds to a more distorted acreage allocation, with respect to the free trade equilibrium  $E$ , than the initial equilibrium  $F$ , though for the overall domestic agricultural sector the share of total support granted through decoupled instruments increases when shifting from the  $F$  to the  $G$  situation. Thus, Figure 4.5 suggests that production and trade distorting effects may be aggravated when implementing decoupled agricultural support instruments while coupled instruments remain in force.

This last result is very important as regards to future discussions on eligibility conditions to the "green box" which are likely to occur during the Millenium Round. In fact, it suggests that agricultural support measures should not be judged on an individual basis, as implied by the current URAA green box definition, but as part of a policy package. In the same way, supposedly decoupled measures should not be automatically included in the "green box" since their practical production or trade distorting effects may be far different from their theoretical ones.

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<sup>38</sup> Obviously it does not mean that the considered support policy does not generate any distortion on the corresponding agricultural markets. Furthermore, in a situation where the total agricultural land area would not be fixed, the considered support policy would lead to increase the land area used in agricultural production to the detriment of alternative uses (such as forestry or recreational purposes for example), due to the increasing marginal return to land used in agriculture.

**Figure 4.5. Effects of the fixed lump-sum payment on acreage allocation in a multi-output, multi-instrument framework**



**4.3. Are the green box decoupling criteria for direct payments to producers well-designed: Taking into account adjustments on the land market and/or in the number of farmers**

Annex 2 of the URAA provides the eligibility criteria to the green box. As far as direct payments to producers for income support purpose are concerned, Annex 2 states that such instruments are considered as decoupled from production and trade if they meet the two basic criteria set out in point 1:

(i) the support in question shall be provided through publicly-funded government programme ... not involving transfers from consumers;

(ii) the support in question shall not have the effect of providing price support to producers;

plus the five policy-specific criteria set out in point 6:

(i) eligibility for such payments shall be determined by clearly-defined criteria such as income, status of producer or landowner, factor use or production level in a defined and fixed base period;

(ii) the amount of such payments in any given year shall not be related to, or based on, the type or volume of production (including livestock units) undertaken by the producer in any year after the base period;

- (iii) the amount of such payments in any given year shall not be related to, or based on, the prices, domestic or international, applying to any production undertaken in any year after the base period;
- (iv) the amount of such payments in any given year shall not be related to, or based on, the factors of production employed in any year after the base period;
- (v) no production shall be required in order to receive such payments.

In the previous section it has been shown that these green box decoupling criteria duplicate the working of the theoretical lump-sum payments, provided that the considered framework corresponds to the one traditionally used in the welfare theory. But, as soon as one relaxes one or more hypotheses of this usual simplified framework, even fixed lump-sum payments do have effects on producers' decisions, so that they are not fully decoupled. In other words, in practice, and as far as agricultural production is concerned, fully decoupled policy instruments do not exist since it is virtually impossible to break the link between income support to farmers and their production decisions.

In this section, contrary to most existing studies, we hold the hypotheses of the usual model of the welfare theory. Then, we show that even within this usual framework, one may question the consistency of the green box decoupling criteria.

#### ***4.3.1. The key role of factor mobility assumptions***

In this paragraph, the analysis relies on an analytical framework, which allows it to highlight the key role of factor mobility assumptions in determining the effects on production of alternative income support policy instruments. The proposed model expands the one developed by Hertel (1989) by considering two sectors.<sup>39</sup>

##### ***4.3.3.1. The theoretical model***

The proposed framework is a static partial equilibrium model with two perfectly competitive agricultural sectors indexed by  $j = a, v$ . Each sector is characterised by a mono-product, constant returns to scale production technology. The production level of sector  $j$  is denoted  $y^j$ . Each sector uses three inputs: an aggregate variable input  $x^j$  (such as fertilisers, pesticides, feed, etc.), a specific primary factor of production available in fixed quantity  $K^j = \overline{K^j}$  (such as an aggregate of labour and capital, for example), and another primary factor of production  $l^j$  (such as land, for example). Total supply of the variable input is perfectly elastic at price  $w^j$ , whereas total supply of land ( $\overline{L}$ ) is

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<sup>39</sup> Our proposed model is concerned with the supply side only while Hertel's model takes into account both the supply and the demand side.

assumed to be fixed. Hence, production technologies of both sectors are interrelated only due to competition for the available land. This latter may then be considered as an "allocatable fixed" factor. Each sector determines its output supply and input derived demands by maximising its profit  $\pi^j$  subject to technological and market constraints. It is assumed that output prices  $p^j$  are exogenous.

Public intervention in both sectors can take various forms: production subsidies ( $sp^j$ ), variable input subsidies ( $sv^j$ ) and direct payments to producers based on primary factors of production ( $sa^j$  for the allocatable fixed factor and  $sf^j$  for the specific factors).

The profit-maximising programme of each sector proceeds as a usual two-stage process (see, e.g., Chambers and Just, 1989). In the first stage, the output and variable input optimal quantities are determined for a given land allocation. This first sub-programme may be written as:

$$\begin{aligned} & \pi^j(p^j, sp^j, w^j, sv^j, l^j, \bar{K}^j) \\ & = \max_{y^j, x^j} \left[ (p^j + sp^j)y^j - (w^j - sv^j)x^j ; y^j = f^j(x^j, l^j, \bar{K}^j) \right] \quad j = a, v \end{aligned} \quad (1)$$

where  $y^j = f^j(x^j, l^j, \bar{K}^j)$  is the production function of sector  $j$ .

Programme (1) defines a restricted profit function which is linearly homogeneous and convex in prices and subsidies; monotonically increasing in the output price, the output subsidy and the variable input subsidy; monotonically decreasing in the variable input price, and monotonically increasing and concave in land and the specific factor.

In the second stage, optimal land allocation is determined by solving the following sub-programme:

$$\begin{aligned} & \tilde{\pi}^j(p^j, sp^j, w^j, sv^j, \lambda^j, sa^j, \bar{K}^j) \\ & = \max_{l^j} \pi^j(p^j, sp^j, w^j, sv^j, l^j, \bar{K}^j) + sa^j.l^j - \lambda^j.l^j \quad j = a, v \end{aligned} \quad (2)$$

where  $\lambda^j$  is the price of land in sector  $j$ , as defined later. The first-order conditions of the maximisation sub-programme (2) yield:

$$\pi_l^j(p^j, sp^j, w^j, sv^j, l^j, \bar{K}^j) + sa^j - \lambda^j = 0 \quad j = a, v \quad (3)$$

where  $\pi_l^j(\cdot)$  denotes the partial derivative of the restricted profit function with respect to land. Equations (3) implicitly define the derived demands for land of both sectors:

$$ld^j(\cdot) = ld^j(p^j, sp^j, w^j, sv^j, sa^j, \bar{K}^j, \lambda^j) \quad j = a, v \quad (4)$$

The derived demand for land of sector  $j$  depends on output and input prices and subsidies prevailing in sector  $j$ , as well as on the land-based direct payment and the specific factor level observed in this sector. All arguments of the land derived demand functions (4) except the price of land  $\lambda^j$ , are exogenous. In fact, the land prices  $\lambda^j$  are endogenous and determined through the land market-clearing equations.

The issue at stake is thus to specify land supply functions for both sectors. Most agricultural production analyses consider land as a homogeneous factor (see, e.g., Coyle, 1993; Guyomard et al., 1996; Oude Lansink and Peerlings, 1996). In this standard case, the total supply of land is fixed at level  $\bar{L}$  and the land market-clearing equation is simply:

$$\sum_{j=a,v} l^j(\cdot) = \bar{L} \quad (5)$$

Thus, the equilibrium price of land is the same for both sectors:

$$\lambda^a = \lambda^v = \lambda \quad (6)$$

Therefore, using equations (4), (5) and (6), the equilibrium price of land, as well as the optimal land allocation to each sector can be written as functions of exogenous variables:

$$\lambda(\cdot) = \lambda(p^v, p^a, sp^v, sp^a, w^v, w^a, sv^v, sv^a, sa^v, sa^a, \bar{K}^v, \bar{K}^a, \bar{L}) \quad (7)$$

$$l^j(\cdot) = l^j(p^v, p^a, sp^v, sp^a, w^v, w^a, sv^v, sv^a, sa^v, sa^a, \bar{K}^v, \bar{K}^a, \bar{L}) \quad j = a, v \quad (8)$$

Optimal output supply functions and variable input derived demand functions of each sector are then obtained by applying Hotelling's lemma to each sector-specific profit function (1), evaluated at the optimal land allocation (8):

$$y^j(\cdot) = y^j \left( p^j, sp^j, w^j, sv^j, l^j(p^v, p^a, sp^v, sp^a, w^v, w^a, sv^v, sv^a, sa^v, sa^a, \bar{K}^v, \bar{K}^a, \bar{L}), \bar{K}^j \right) \quad j = a, v \quad (9)$$

$$-x^j(\cdot) = x^j \left( p^j, sp^j, w^j, sv^j, l^j(p^v, p^a, sp^v, sp^a, w^v, w^a, sv^v, sv^a, sa^v, sa^a, \bar{K}^v, \bar{K}^a, \bar{L}), \bar{K}^j \right) \quad j = a, v \quad (10)$$

Hence, due to the land constraint, optimal allocation of land to one sector, as well as this sector's output supply and variable input derived demand, depend not only on prices, subsidies, the land-based direct payment and the specific factor level prevailing in this sector but also on prices, subsidies, the land-based direct payment and the specific factor level observed in the other sector.

Although the land homogeneity assumption is very common in applied agricultural models, essentially because of its tractability and its parsimony, it is not realistic and moreover embodies strong assumptions on price elasticity of supply (Hertel, 1999). The capacity of a given plot of land to produce a particular farm product varies with soil type, location in the watershed, and climatic conditions. These characteristics all combine to determine the yield, given a certain level of nonland inputs. Models based on the homogeneity assumption of land will then overstate supply response, since they do not take into account the agronomic and climatic constraints placed on the production of specific farm commodities.

Computable General Equilibrium (CGE) models focused on agricultural sectors usually attempt to capture these constraints in a tractable fashion.<sup>40</sup> To our knowledge, three main approaches have been used to model heterogeneity of land, and more generally, of primary factors of production. The first one consists in specifying a transformation function, which takes total land as an input and distributes it among various sectors in response to relative rental rates. The standard parametric function used in CGE models is the Constant Elasticity of Transformation (CET) function, where the elasticity of transformation is a synthetic measure of land heterogeneity (see, e.g., Hertel and Tsigas, 1988; Peerlings, 1993). The second approach has been developed by Robidoux et al. (1989) in their Canadian CGE model. They assume different types of land, which substitute imperfectly each other in the production of a given agricultural good. The third approach, which has been used for example in the Walras model (Burniaux et al., 1990), is based on the specification of migration functions that determine factor flows between the various considered sectors.<sup>41</sup>

For parsimony considerations, we follow the Walras model approach by distinguishing two types of land and specifying migration functions. More specifically, we assume that total available land  $\bar{L}$  may be broken down into two land types, so that both sectors face two land supply functions. These functions are indexed by  $j = a, v$  in order to indicate that each type of land is more well-suited to the specific production process of the corresponding sector. However, land is not a specific factor for each

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<sup>40</sup> In partial equilibrium (PE) models, a continuum of land types is often assumed (see, e.g., Lichtenberg, 1989; Antle and Just, 1990; Caswell et al., 1990). Depending on data availability, this continuum is summarised by an observed index, such as the Land Capability Class in the US.

<sup>41</sup> This approach has also been used by Abler and Shortle (1992).

sector since "land migration" between sectors is allowed. Therefore, due to this migration possibility, each land type supply function depends on the prices of both land types. Thus, we have:

$$l_o^v(.) = l_o^v(\lambda^a, \lambda^v) \quad (11)$$

$$l_o^a(.) = \bar{L} - l_o^v(.) = \bar{L} - l_o^v(\lambda^a, \lambda^v) = l_o^a(\lambda^a, \lambda^v) \quad (12)$$

where the supply function of land type  $j$ ,  $l_o^j(.)$ , is increasing in its own price  $\lambda^j$ , decreasing in the price of the other type of land and homogeneous of degree zero in land prices.

In other words, the derived demand for each type of land (resulting from the optimisation programme of the corresponding sector) depends only on its own price whereas the supply of each type of land is a function of both land type prices. One may notice that the land homogeneity assumption corresponds to a particular case of the more general heterogeneity assumption, where land supply functions (11) and (12) are perfectly elastic with respect to both land type prices. In the following, we will carry on with the general land heterogeneity specification.

Finally, the total profit of each sector is defined as:

$$\hat{\pi}^j(.) = \pi^j \left( p^j, sp^j, w^j, sv^j, l^j(p^v, p^a, sp^v, sp^a, w^v, w^a, sv^v, sv^a, sa^v, sa^a, \bar{K}^v, \bar{K}^a, \bar{L}), \bar{K}^j \right) + sf^j \cdot \bar{K}^j \quad j = a, v \quad (13)$$

This profit is homogeneous of degree one with respect to the specific factor  $\bar{K}^j$ . Hence, we may write:

$$\pi_{\bar{K}^j}^j(.) + sf^j = \mu^j \quad j = a, v \quad (14)$$

where  $\mu^j$  denotes the opportunity cost or the shadow value of the specific factor in sector  $j$ .

#### 4.3.1.2. Comparative static analysis

The comparative statics of land allocation, land prices and specific factor shadow values are obtained by total differentiation of equations (3), (11), (12) and (14), and solving for  $d\lambda^j, d\lambda^j, d\mu^j$ . The corresponding system is reported in appendix 1. The comparative statics of each endogenous variable is given by<sup>42</sup>:

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<sup>42</sup>  $\pi_{qz}^j(.)$  denotes the second partial derivative of the restricted profit function of sector  $j$  (corresponding to programme (1)) with respect to variables  $q^j$  and  $z^j$ . Exponent  $j$  of variables has been omitted for simplicity.

$$dl^v = \frac{-1}{d} \left[ lo_{\lambda^v}^v \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) + lo_{\lambda^a}^a \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) + \pi_{ll}^a \cdot lo_{\lambda^a}^v \cdot d\bar{L} \right] \quad (15)$$

$$dl^a = \frac{1}{d} \left[ lo_{\lambda^v}^v \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) + lo_{\lambda^a}^a \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) + (\pi_{ll}^v \cdot lo_{\lambda^v}^v - 1) \cdot d\bar{L} \right] \quad (16)$$

$$d\lambda^v = \frac{1}{d} \left[ -(1 + lo_{\lambda^a}^v \cdot \pi_{ll}^a) \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) - lo_{\lambda^a}^v \cdot \pi_{ll}^a \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) - \pi_{ll}^v \cdot \pi_{ll}^a \cdot lo_{\lambda^a}^v \cdot d\bar{L} \right] \quad (17)$$

$$d\lambda^a = \frac{1}{d} \left[ lo_{\lambda^v}^v \cdot \pi_{ll}^a \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) - (1 - lo_{\lambda^v}^a \cdot \pi_{ll}^v) \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) + \pi_{ll}^a \cdot (\pi_{ll}^v \cdot lo_{\lambda^v}^a - 1) \cdot d\bar{L} \right] \quad (18)$$

$$d\lambda^v = \frac{-1}{d} \left[ lo_{\lambda^v}^v \cdot \pi_{kl}^v \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) + lo_{\lambda^a}^a \cdot \pi_{kl}^a \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) + \pi_{ll}^v \cdot \pi_{kl}^a \cdot lo_{\lambda^a}^v \cdot d\bar{L} \right] + \pi_{kp}^v \cdot (dp^v + dsp^v) + \pi_{kw}^v \cdot (dw^v - dsv^v) + \pi_{kk}^v \cdot d\bar{K}^v + dsf^v \quad (19)$$

$$d\lambda^a = \frac{1}{d} \left[ lo_{\lambda^v}^v \cdot \pi_{kl}^a \cdot (\pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (dw^v - dsv^v) + \pi_{lk}^v \cdot d\bar{K}^v + ds\alpha^v) + lo_{\lambda^a}^a \cdot \pi_{kl}^a \cdot (\pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (dw^a - dsv^a) + \pi_{lk}^a \cdot d\bar{K}^a + ds\alpha^a) + \pi_{ll}^a \cdot (\pi_{ll}^v \cdot lo_{\lambda^v}^a - 1) \cdot d\bar{L} \right] + \pi_{kp}^a \cdot (dp^a + dsp^a) + \pi_{kw}^a \cdot (dw^a - dsv^a) + \pi_{kk}^a \cdot d\bar{K}^a + dsf^a \quad (20)$$

with  $d = \pi_{ll}^v \cdot lo_{\lambda^v}^v - \pi_{ll}^a \cdot lo_{\lambda^a}^v - 1 < 0$

Once the comparative statics of land allocation is determined, the comparative statics of output supplies and variable input derived demands are easily obtained:

$$dy^j = \pi_{pp}^j \cdot (dp^j + dsp^j) + \pi_{pw}^j \cdot (dw^j - dsv^j) + \pi_{pl}^j \cdot dl^j + \pi_{pk}^j \cdot d\bar{K}^j \quad j = a, v \quad (21)$$

$$-dx^j = \pi_{wp}^j \cdot (dp^j + dsp^j) + \pi_{ww}^j \cdot (dw^j - dsv^j) + \pi_{wl}^j \cdot dl^j + \pi_{wk}^j \cdot d\bar{K}^j \quad j = a, v \quad (22)$$

Equations (15) and (16) provide the comparative statics of land allocation between both sectors. They show that land use in sector  $j$  is increasing in the total quantity of available land  $\bar{L}$ , in its own land-based direct payment  $sa^j$  and in its own output subsidy  $sp^j$  under the assumption of non-inferiority of the land input. One also sees that land use in sector  $j$  is decreasing in both the land-based direct payment and the output subsidy implemented in the other sector. The impact of a change in each sector's variable input subsidy ( $sv^j$ ) or specific factor level ( $\bar{K}^j$ ) on land use in sector  $j$  is

ambiguous. It depends on substitution-complementarity relationships between land and both other inputs (i.e. the variable input and the specific factor) in the production technologies of each sector (i.e. on the respective signs of  $\pi_{lw}^j$  and  $\pi_{l\bar{K}}^j$ ,  $j = a, v$ ).

Equations (21) clearly show that the output supply in sector  $j$ , still under the assumption of non-inferiority of the land input, is increasing in the total quantity of available land, its own land-based direct payment and its own output subsidy, while it is decreasing in both the land-based direct payment and the output subsidy applied in the other sector. Obviously, the output supply response of sector  $j$  to a change in variable input subsidies or specific factor levels is also ambiguous.

At this stage, one may notice that in the particular case where land is homogeneous (i.e.,  $|l\sigma_{\lambda}^j| \rightarrow \infty$ ), equations (15) and (16) become respectively:

$$dl^v = \frac{-1}{\pi_{ll}^a + \pi_{ll}^v} \left[ \begin{aligned} & \left( \pi_{lp}^v \cdot (dp^v + dsp^v) + \pi_{lw}^v \cdot (d\omega^v - dsv^v) + \pi_{l\bar{K}}^v \cdot d\bar{K}^v + ds a^v \right) \\ & - \left( \pi_{lp}^a \cdot (dp^a + dsp^a) + \pi_{lw}^a \cdot (d\omega^a - dsv^a) + \pi_{l\bar{K}}^a \cdot d\bar{K}^a + ds a^a \right) + \pi_{ll}^a \cdot d\bar{L} \end{aligned} \right] \quad (23)$$

$$dl^a = d\bar{L} - dl^v \quad (24)$$

Hence, all results regarding the impact of the various considered policy instruments on land allocation and output supplies presented above are also valid under the land homogeneity assumption.

#### 4.3.1.3. Factor mobility and the green box decoupling criteria for direct payments to producers

The previous comparative static equations can now be used to discuss the validity of some policy-specific eligibility criteria to the green box. We focus attention on criteria (ii), (iii) and (iv) of point 6 of Annex 2 of the URAA. Let us begin with criterion (iv). It stipulates that to be considered as decoupled a factor-based direct payment must be calculated on the basis of the used quantity of this factor observed during the base period. It is worth mentioning that in contrast to criterion (ii), criterion (iv) does not specify whether it applies at the farm, the concerned agricultural sub-sector (crop or livestock sub-sectors for example) or the whole agricultural sector level. This (probably intentional) imprecision is however of major importance when analysing the degree of decoupling of such direct payments to producers.<sup>43</sup>

The comparative static results stemming from our theoretical framework clearly show that the production effects (i.e. the degree of decoupling) of the direct payments based on specific factors  $sf^j$

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<sup>43</sup> As an example, CAP crop land-based compensatory payments, which are limited to a national historical base area in each EU Member State, comply with criterion (iv) if this latter is interpreted at the crop sub-sector level. In contrast, these compensatory payments do not conform to this criterion if it is interpreted at the farm level.

are far different from those of the land-based direct payments  $sa^j$ . In fact, the direct payments  $sf^j$  conform to criterion (iv) defined at either the farm or the agricultural sub-sector level, whereas land-based direct payments  $sa^j$  comply with criterion (iv) defined at the level of the whole agricultural sub-sectors  $a$  and  $v$ .<sup>44</sup>

Hence, the comparative static equations (15) to (21) show that specific factor-based direct payments  $sf^j$  have effectively no effects on land prices, land allocation and, consequently, on output supplies. They only induce a positive effect on the shadow values of both specific factors (see equations (19) and (20)). Therefore, such direct payments are effectively decoupled from production. In contrast, land-based direct payments actually affect land prices, land allocation and so output supplies. Thus, such a policy instrument may not be considered as decoupled from production even though it complies with criterion (iv) if interpreted at the whole sector level.<sup>45</sup>

At this stage, two remarks are in order. Firstly, equations (15) to (21) show that even if specific factor-based direct payments  $sf^j$  are adjusted to domestic or international price changes, they will remain neutral with respect to domestic output supplies. Therefore, in that case, criterion (iii) is redundant. One must underline however that this result relies on our simplified framework which does not take into account risk, dynamics, financial market constraints, etc. Secondly, it is obvious from equations (15) to (21) that even if specific factor-based direct payments  $sf^j$  are differentiated according to the sub-sector they are applied to (i.e. if  $dsf^v$  differs from  $dsf^a$ ), they also will remain neutral regarding domestic output supplies. In that case, criterion (ii) also becomes redundant.

Consider now the land-based direct payments. It is easily shown from equations (15) to (21) that criterion (ii) may be inconsistent. More precisely, criterion (ii) stipulates that eligible direct payments must be independent from the type or volume of production undertaken by the producer in any year after the base period. In our theoretical framework, this criterion implies that our land-based direct payments implemented in each sub-sector should be equal (i.e.  $dsa^v = dsa^a$ ). Equations (23) and (24) suggest that criterion (ii) in addition to criterion (iv) effectively ensure decoupling when land is a homogeneous factor, since in that case, we have:

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<sup>44</sup> That is, for example, at the crop sector level if sub-sector  $a$  corresponds to grains while sub-sector  $v$  relates to oilseeds and protein crops, or at the whole agricultural sector level if sub-sector  $a$  represents animal production and sub-sector  $v$  vegetal production.

<sup>45</sup> One may notice that the same result would be obtained in a theoretical framework where our current agricultural sub-sectors  $a$  and  $v$  would correspond to two non-joint production processes of a unique agricultural sub-sector or farm and criterion (iv) interpreted at the sub-sector or the farm level.

for  $dp^j = dsp^j = dw^j = dsv^j = \overline{dK^j} = \overline{dL} = 0 \quad j = a, v$

$dl^v = dl^a = dy^v = dy^a = 0$  if and only if  $dsa^v = dsa^a$

However, when land is a heterogeneous factor, even uniform land-based direct payments may affect domestic output supplies (see equations (15), (16) and (21)). Hence, in that case, criterion (ii) in addition to criterion (iv) fail to ensure decoupling since a direct payment system conforming to both criteria may have significant effects on domestic production. Furthermore, equations (15) and (16) clearly show that when land is heterogeneous, the decoupled land-based direct payment system is a package of sub-sector differentiated payments satisfying the following equation:

$$lo_{\lambda^v}^v \cdot dsa^v = -lo_{\lambda^a}^v \cdot dsa^a \quad (25)$$

Hence, under the land heterogeneity assumption, criterion (ii) is inconsistent since it makes no decoupled direct payments to producers eligible for the green box. This result is essential with regards to the future discussions on the green box definition during the Millennium Round since, quite obviously, primary factors used in agricultural production, particularly land, are not homogeneous. Furthermore it is likely that their degree of heterogeneity varies across countries.

In this respect, equation (25) emphasises the crucial importance of migration parameters  $lo_{\lambda^v}^v$  and  $lo_{\lambda^a}^v$  with respect to the degree of coupling/decoupling of direct payments based on an allocatable fixed factor. In fact, the situation where one of these migration parameters is null corresponds to the specific factor case previously described. In such a case, as has already been mentioned, land-based direct payments remain production neutral, and so decoupled, even if they are differentiated across sub-sectors. On the other hand, for positive and finite values of migration parameters, only differentiated land-based direct payments are production neutral and may be considered as decoupled.

All these results suggest that the same direct payment system applied in two countries may lead to very different production (and trade) effects, provided that the concerned agricultural production technologies and factor mobility situations are different in both countries. In other words, one may not qualify a direct payment system as coupled or decoupled without considering the "technological" characteristics of the targeted sector (more generally of the whole economy), especially its production technology and the extent of primary factor heterogeneity or mobility. Any attempt to measure the degree of decoupling of direct payment systems should ideally take these characteristics into account.

#### ***4.3.2. The key role of adjustments on the land market and in the number of farmers***

In this paragraph, the analysis relies on an analytical framework, which allows it to highlight the key role of simultaneous adjustments in the number of farmers and on land market as regards to the effects

on production and trade of various income support policy instruments. The proposed model is inspired from the one developed by Leathers (1992) in order to examine the impact of policy instruments on the number of producers.

#### 4.3.2.1. The theoretical model

A potential agricultural producer  $n$  has an initial endowment in land equal to  $li_n$ . He faces perfectly elastic supplies for all factors of production, including land, and takes their prices as given. However the agricultural industry experiences a rising supply curve for land. It is thus an increasing-cost industry (Hughes, 1980). Land can be acquired/let through rental only. The buying/selling price of land is assumed to be adequately approximated by the discounted sum of future rental values so that a prediction about the direction of the rental price is equivalent to a prediction about the direction of the buying/selling price (Leathers, 1992).

There are  $N$  potential agricultural producers and  $N$  is large. In order to simplify presentation and analysis, we assume that they have the same production function.

We consider four alternative income support instruments: a decoupled subsidy without mandatory production  $mno$ , a decoupled subsidy with mandatory production  $mo$ , a land subsidy  $t$ , and a production subsidy  $sp$ .

#### Agricultural producer behaviour

The profit-maximising program of a potential agricultural producer  $n$  may be defined as (the index  $n$  is omitted):

$$\begin{aligned} \max_{y,x,l} (p + sp)y - wx - r(l - li) + tl + mo + mno \quad s.t. \quad y = f(x, l, nf) \\ \equiv \pi(p + sp, w, r - t, nf) + rli + mo + mno \end{aligned} \quad (26)$$

where  $y$  denotes the agricultural output,  $x$  an aggregate variable input,  $l$  the amount of land used for production and  $nf$  the family labour. The price of output is  $p$ , the production subsidy is  $sp$ , the price of the variable input is  $w$ , the rental price of land is  $r$ , the land subsidy is  $t$ , the decoupled subsidy with mandatory production is  $mo$  and the decoupled subsidy without mandatory production is  $mno$ . The production function  $y = f(x, l, nf)$  is assumed well-defined for all non-negative variable input, land and family labour quantities. It is everywhere twice-continuously differentiable, non-negative, non-decreasing and concave. Program (26) defines a profit function  $\pi(p + sp, w, r - t, nf)$  which is well-defined for all positive prices, everywhere twice-continuously differentiable, non-negative, increasing, linearly homogeneous and convex in prices, increasing and concave in family labour (Diewert, 1974). In program (26),  $r(l - li)$  represents the cost of renting additional land at price  $r$  per unit (in that case,

$r(l - li) \geq 0$ ) or the earnings from leasing part or all of initial land endowment, also at price  $r$  per unit (in that case,  $r(l - li) \leq 0$ ).

Output supply, land demand and variable input demand equations are obtained by applying Hotelling's lemma, i.e.,

$$\partial\pi(p + sp, w, r - t, nf) / \partial p = \pi_p(p + sp, w, r - t, nf) = y(p + sp, w, r - t, nf) \quad (27)$$

$$-\partial\pi(p + sp, w, r - t, nf) / \partial r = -\pi_r(p + sp, w, r - t, nf) = l(p + sp, w, r - t, nf) \quad (28a)$$

$$-\partial\pi(p + sp, w, r - t, nf) / \partial w = -\pi_w(p + sp, w, r - t, nf) = x(p + sp, w, r - t, nf) \quad (28b)$$

The individual supply function for the agricultural commodity is an increasing function of the output price, the production subsidy and the land subsidy. It is decreasing in the variable input price and the rental price of land, and it does not depend on decoupled subsidies with or without mandatory production (equation (27)). The individual derived demand function for land is an increasing function of the output price, the production subsidy and the land subsidy. It is decreasing in the rental price of land, and it does not depend on decoupled subsidies with or without mandatory production. Impacts of changes in the variable input price on land demand depend on (Marshallian) substitution and complementarity relationships between production factors  $x$  and  $l$  (equation (28a)).

### System equilibrium equations

The model involves three equilibrium equations. The first one is the equilibrium condition in the output market. It requires the aggregate supply of the agricultural commodity to equal the aggregate demand (i.e., domestic demand and exports). The second one is the equilibrium condition in the land market, which implies that there is zero excess supply in this market. The third equilibrium equation corresponds to the entry-exit condition.

The equilibrium equation in the agricultural commodity market may be written as:

$$\sum_K y(p + sp, w, r - t, nf) = K \cdot \pi_p(p + sp, w, r - t, nf) = DD(p) + DE(p) \quad (29)$$

where  $K$  is the number of producers who effectively produce,  $DD(p)$  is the domestic aggregate demand function and  $DE(p)$  is the export aggregate demand function.

The equilibrium equation in the land market may be written as:

$$\sum_N li + Sl(r, ls) = K \cdot l(p + sp, w, r - t, nf) + Dl(r, ld) \quad (30)$$

Land supply is the sum of initial endowments in land of the  $N$  potential farmers, plus an upward-sloping function  $Sl(r, ls)$ , which corresponds to land supplied by land owners who are not potential farmers ( $Sl_r \geq 0$ ). Land demand is the sum of derived demands for land by the  $K$  farmers who decide to enter and produce the agricultural commodity, plus a downward-sloping function  $Dl(r, ld)$ , which corresponds to land demanded by land users who are not potential farmers ( $Dl_r \leq 0$ ). Parameters  $ls$  and  $ld$  are function shifters.

The last equilibrium equation corresponds to the entry-exit condition. A potential farmer will choose not to enter if he can earn more money by leasing out all his land endowment and holding the best possible alternative in terms of wages ( $PA$ ), i.e., if:

$$\pi(p + sp, w, r - t, nf) + rli + mo + mno \leq PA + rli + mno \quad (31)$$

As a result, a potential farmer with initial endowment  $li$  will be indifferent between farming and not farming if:

$$\pi(p + sp, w, r - t, nf) + mo = PA \quad (32)$$

From (32), one notes that the entry-exit decision does not depend on the initial land endowment  $li$ . However this latter has a proportional impact, for a given land rental price, on total profit a farmer can earn by entering and producing (see program (26)). One also notes that the entry-exit decision does not depend on the decoupled subsidy without mandatory production ( $mno$ ), but on the decoupled subsidy with mandatory production ( $mo$ ).

At this stage, it is useful to explain the working of both types of decoupled subsidies. Without loss of generality, let us assume that the initial situation corresponds to a no support regime with  $K_i$  farmers who produce. Let us now assume that the government seeks to support farmers' incomes by means of a decoupled subsidy without mandatory production. Equation (31) implies that the latter is granted to the  $K_i$  farmers only, even if some of them decide to go out and not to produce in the new situation, but not to new entrants. Let us now assume that the income support instrument is a decoupled subsidy with mandatory production. Equation (31) shows then that the latter is granted to any farmer who decides to produce in this new regime, but not to farmers who produced in the initial situation and now prefer to go out and lease out all their land endowment. These assumptions allow us to write the entry and exit conditions in only one equation, i.e., equation (32).

The solution of equations (29), (30) and (32) gives the equilibrium price of the agricultural commodity  $p$ , the equilibrium rental price of land  $r$ , and the equilibrium number of farms,  $K$ , composing the

industry. The analysis of farm programs proceeds then by totally differentiating (29 (30) and (32), and solving the resulting system.

#### 4.3.2.2. *The impact of income support policy instruments on trade*

We directly derive the comparative static effects of the four considered policy instruments on the price of the agricultural output, the rental price of land and the number of farms/farmers. Then, using these comparative static results, we may obtain the effects of policy instruments on exports, from the export aggregate demand function  $DE(p)$ . Details of calculations are provided in appendix 2. The main results of the comparative static analysis are summarised in Table 4.1.

At this stage, one may underline that the four considered instruments have been chosen because they cover a range of measures complying more or less with the basic criteria of point 1 and the policy-specific criteria of point 6 of Annex 2 of the URAA. Indeed, according to the green box requirements, the decoupled subsidy without mandatory production *mno* may actually be considered as decoupled since it complies with all criteria of points 1 and 6. The decoupled subsidy with mandatory production *mo* is less decoupled than *mno* since it does not comply with criterion (v) of point 6. The land subsidy *t* is even less decoupled than *mo* since it does not comply with both criteria (iv) and (v) of point 6. Finally, according to the green box definition, the production subsidy *sp* is the less decoupled instrument since it does not comply with criteria (ii) and (v) of point 6, nor with the basic criteria (ii) of point 1.

Globally, results reported in Table 4.1 indicates that the basic and the policy-specific decoupling criteria of both points 1 and 6 are well-designed as far as both the most decoupled (i.e., *mno*) and the least decoupled (i.e., *sp*) instruments are considered. Indeed, the decoupled subsidy without mandatory production, which complies with all criteria, has actually no trade distortion effect and no effect on production. At reverse, the production subsidy, which does not comply with one basic and two policy-specific decoupling criteria has actually a positive trade distortion effect and a positive effect on production. In other words, if one considers only these two policy instruments, criteria of points 1 and 6 of Annex 2 do ensure decoupling and do ensure that a policy instrument not complying with all the criteria is less decoupled (i.e., has greater trade distortion effects) than a policy instrument in full compliance.

However, when taking into account both other instruments the consistency of these criteria is less obvious.

**Table 4.1. The comparative static analysis of alternative income support policy instruments**

	<b>Impact of a decoupled subsidy without mandatory production (<i>mno</i>) on</b>	
Output price	0	
Number of farms/farmers	0	
Rental price of land	0	
Agricultural output exports	0	
	<b>Impact of a decoupled subsidy with mandatory production (<i>mo</i>) on</b>	
Output price	Ambiguous: - when $\varepsilon_y^l \leq 1$ ; +/- when $\varepsilon_y^l \geq 1$	
Number of farms/farmers	+	
Rental price of land	Ambiguous: + when $\varepsilon_l^y \leq 1$ ; +/- when $\varepsilon_l^y \geq 1$	
Agricultural output exports	Ambiguous: + when $\varepsilon_y^l \leq 1$ ; +/- when $\varepsilon_y^l \geq 1$	
	<b>Impact of a land subsidy (<i>l</i>) on</b>	
	<b>General case</b>	<b>Particular case (<math>Sl_r = Dl_r = 0</math>)</b>
Output price	-	0
Number of farms/farmers	Ambiguous: + when $\varepsilon_l^y \leq 1$ ; +/- when $\varepsilon_l^y \geq 1$	0
Rental price of land	+	+
Agricultural output exports	+	0
	<b>Impact of a production subsidy (<i>sp</i>)</b>	
Output price	-	
Number of farms/farmers	Ambiguous: + when $\varepsilon_y^l \leq 1$ ; +/- when $\varepsilon_y^l \geq 1$	
Rental price of land	+	
Agricultural output exports	+	

**The decoupled subsidy with mandatory production *mo***

The effects of a decoupled subsidy with mandatory production (*mo*) on the endogenous variables and on domestic trade are given by:

$$\det M \cdot (dp / dmo) = -K\pi_r \pi_p (1 - \varepsilon_y^l) - (Sl_r - Dl_r)\pi_p \quad (33)$$

$$\det M \cdot (dr / dmo) = K\pi_{pp} (-\pi_r)(1 - \varepsilon_l^y) - (DD_p + DE_p)(-\pi_r) \quad (34)$$

$$\det M \cdot (dK / dmo) = K^2 (\pi_{pp} \pi_{rr} - \pi_{pr}^2) + K \pi_{pp} (Sl_r - Dl_r) - (DD_p + DE_p)(K \pi_{rr} + Sl_r - Dl_r) > 0 \quad (35)$$

$$dX / dt = DE_p \cdot (dp / dmo) \quad (36)$$

where  $\varepsilon'_y = \partial \log y(p + sp, w, l, nf) / \partial \log l$  is the restricted Marshallian supply elasticity of output  $y$  with respect to land quantity  $l$ , while  $\varepsilon'_l = \partial \log l(y, w, r - t, nf) / \partial \log y$  is the restricted Hicksian derived demand elasticity of land  $l$  with respect to output level  $y$ .

Hence, the decoupled subsidy with mandatory production has only one unambiguous effect: a positive effect on the number of farms/farmers (equation (35)). The impacts of the decoupled subsidy with mandatory production on all other variables are indeterminate and depend closely on the levels of  $\varepsilon'_y$  and  $\varepsilon'_l$  relative to one.

The effect of the decoupled subsidy with mandatory production on the price of the agricultural commodity (equation (33)) is unambiguously negative when the restricted Marshallian supply elasticity of output with respect to land quantity ( $\varepsilon'_y$ ) is lower than unity. When this elasticity is strictly greater than one, the effect can become positive if the positive impact of the first right-hand side term of (33) outweighs the negative impact of the second right-hand side term of (33). The effect on the rental price of land (equation (34)) is unambiguously positive when the restricted Hicksian derived demand elasticity of land with respect to output level ( $\varepsilon'_l$ ) is lower than unity. When this elasticity is strictly greater than one, the effect can become negative if the negative impact of the first right-hand side term of (34) outweighs the positive impact of the second right-hand side term of (34). One may notice that convexity in prices of the profit function defined by program (26) implies that the product of elasticities  $\varepsilon'_y \cdot \varepsilon'_l$  is always smaller than one. It follows that the decoupled subsidy with mandatory production cannot simultaneously increase the output price and decrease the land price.<sup>46</sup> Finally, the impact of the decoupled subsidy with mandatory production on agricultural commodity exports (equation (36)) is indeterminate. It is positive (respectively, negative) when the price of the agricultural commodity decreases (respectively, increases).

The ambiguous effects of the decoupled subsidy with mandatory production may be explained as follows. All other things being equal, the decoupled subsidy favours the entry of new producers into farming, creating subsequently excess supply in the output market and excess demand in the land market. A new equilibrium of the economy may be obtained through either an output price decrease and an increase in the rental price of land ( $\varepsilon'_y \leq 1$  and  $\varepsilon'_l \leq 1$ ), an output price increase compensated

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<sup>46</sup> If the output price increases, then the land price increases too. And if the land price decreases, then the output price decreases too.

by a higher increase in the rental price of land ( $\varepsilon'_y > 1$  and  $\varepsilon'_r \leq 1$ ), or an output price decrease sufficient to cope with a decrease in the rental price of land ( $\varepsilon'_y \leq 1$  and  $\varepsilon'_r > 1$ ). These price adjustments obviously reduce the incentives for potential producers to enter the sector, but never outweigh the initial positive effect of the decoupled subsidy on the number of farmers.

### The land subsidy

The effects of a land subsidy ( $t$ ) on the endogenous variables and trade are similarly derived from the total differentiation of equations (29), (30) and (32). We obtain:

$$\det M.(dp/dt) = -(Sl_r - Dl_r)\pi_p(-\pi_r) < 0 \quad (37)$$

$$\det M.(dr/dt) = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] - (DD_p + DE_p)(-\pi_r)^2 > 0 \quad (38)$$

$$\det M.(dK/dt) = (Sl_r - Dl_r)[K\pi_{pp}(-\pi_r)(1 - \varepsilon'_y) - (DD_p + DE_p)(-\pi_r)] \quad (39)$$

$$dX/dt = DE_p.(dp/dt) > 0 \quad (40)$$

Thus, the land subsidy will unambiguously decrease the output price (equation (37)), increase the rental price of land (equation (38)) and increase the exports of the agricultural commodity (equation (40)). However, its effect on the number of farms/farmers is indeterminate (equation (39)). When the restricted Hicksian derived demand elasticity of land with respect to output is lower than one, the effect of the land subsidy is to increase the number of farmers. When this elasticity is greater than one, the effect is ambiguous and can become negative if the negative impact of the first right-hand side term of the square brackets in (39) outweighs the positive impact of the second right-hand side term of the square brackets in (39).

Some further results can be wrung out of equations (37) to (40) when  $Sl_r = Dl_r = 0$ . Using the developed expression of  $\det M$  provided in appendix 2, we obtain:

$$dp/dt = 0 \quad (41)$$

$$dr/dt = 1 \quad (42)$$

$$dK/dt = 0 \quad (43)$$

$$dX/dt = 0 \quad (44)$$

Hence, in the particular case where the land supply and demand coming from the rest of the economy correspond to fixed amounts, the only non-zero effect of the land subsidy is to raise the rental price of land by the same amount (equation (42)). Equations (41), (43) and (44) show that, in this particular

case, the land subsidy has no impact on the price of the agricultural product, neither on the number of farms/farmers, nor on the exports of the agricultural commodity.

This last result suggests that a land subsidy may be considered as a decoupled income support instrument, provided that there are restrictions on eligible land (and hence, payments) through the use on an aggregate base area.<sup>47</sup> In other words, this result shows that a policy instrument that does not fully conform to all green box eligibility criteria, as defined in points 1 and 6, may nevertheless have no or minimal distortion effects on trade.

From a EU perspective, the situation depicted in the above particular case corresponds to the current situation in the Common Market Organisation (CMO) for cereals, oilseeds and protein crops (hereafter COP crops), if we consider COP crops as one aggregate only. Therefore, from a WTO negotiation point of view, the EU could rightfully argue that the area payments in force in the EU COP sector have (at least at the aggregate level) minimal trade distortion effects (so could be considered as decoupled), although they do not fully conform to URAA decoupling criteria.<sup>48</sup>

Finally, when comparing the impact on trade of both the decoupled subsidy with mandatory production and the land subsidy with restriction on eligible land, one may question the consistency of the green box decoupling criteria. Indeed, obtained comparative static results suggest that decoupling criteria as defined in point 6 do not necessarily ensure that a policy instrument complying nearly with all criteria is more decoupled (i.e., has lower positive effects on trade) than a policy instrument conforming with less criteria. In fact, it is possible to show that the decoupled subsidy with mandatory production, which comply to all criteria of point 6 but the criterion (v), may have positive effects on trade (when  $\epsilon'_j \leq 1$ ) while the land subsidy, which does not conform to both criteria (v) and (iv), may have no effect on trade, provided that there are restrictions on eligible land.<sup>49</sup>

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<sup>47</sup> Of course, this result is contingent to the model used, i.e., a static framework without risk and uncertainty and considering only one aggregate output.

<sup>48</sup> Obviously, this does not mean that the current EU area payments to COP crops have no effect on the domestic aggregated supply of COP crops with respect to a free market situation. This would be the case only if the current EU base area for COP crops is not larger than the total area which would be devoted to COP crops in a non interventionist regime. The URAA however does not, at least explicitly, strictly constrain to take the free trade situation as the reference situation. For a discussion on the eligibility to the green box of EU compensatory payments granted in both the COP and the beef sectors, see for example Gohin and Guyomard (2000).

<sup>49</sup> In that case, the land subsidy does not comply with criterion (iv) only if this latter is defined at the farm level (cf. the discussion on this point in the previous paragraph).

#### 4.4. Promoting multifunctionality while minimising trade distortion effects: The relative merits of traditional policy instruments

In this paragraph, we keep with the previous theoretical model but we enlarge the analysis in order to deal with the multifunctionality. Our purpose is to classify the previously considered policy instruments according to their ability not only to support farmers' income but also to achieve other goals traditionally assigned to agricultural policies.

we consider only three of the four previous agricultural income support programs: the decoupled subsidy with mandatory production (*mo*), the land subsidy (*t*) and the production subsidy (*sp*). As the only non-zero effect of the decoupled subsidy without mandatory production (*mno*) is to raise, by the same amount, the farmers' individual profit, results of the comparison analysis with other instruments are quite obvious.

Three agricultural policy goals are considered: supporting agricultural income, promoting positive externalities and/or public goods provision and correcting negative externalities (pollution).<sup>50</sup> However, as the WTO discipline requires domestic policy programs to have no, or at most minimal, trade distortion effects or effects on production, the WTO rule of "the minimal induced trade distortion" is considered as a fourth "policy objective".

Each policy objective is directly related to a specific target variable. And the ability of each program to achieve each policy objective is evaluated through its impact on the related target variable. More specifically, the target variable associated with the policy objective of supporting agricultural income (policy objective n°1) is the individual total profit of farmers (denoted *PRO*). We consider that a program inducing an increase (a decrease) in the individual total profit of farmers contributes positively (negatively) to the policy objective of supporting agricultural income. The target variable associated with the policy objective of minimising the trade distortion effect induced by domestic programs (policy objective n° 4) is the agricultural commodity exports (denoted *X*). We consider that a program resulting in an increase (decrease) in agricultural exports goes against (favours) the policy objective of preserving the compatibility of domestic programs with WTO rules. The target variable associated with the policy objective of reducing the negative externalities (policy objective n° 3) is individual yields per hectare (denoted *in* for individual intensification).<sup>51</sup> In other words, we assume that negative externalities arise from an "excessive" use of variable inputs (mainly fertilisers and pesticides). We admit that a program inducing a decrease (an increase) in yields per hectare contributes positively (negatively) to the policy objective of reducing negative externalities arising from

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<sup>50</sup> We do not consider the issue of price and/or income stabilisation as we use a static analysis framework without risk and uncertainty.

<sup>51</sup> Yields have been retained instead of the aggregate variable input use per hectare because the comparative static results are far easier to derive for yields per hectare than for the variable input quantity used per hectare.

intensification of agricultural production. Finally, the target variable associated with the policy objective of maintaining/increasing the provision of positive externalities and/or public goods (policy objective n° 2) is the number of farmers. In fact, following Hueth (2000), we assume that (most) non-food or non-market benefits are directly linked to the number of (high marginal cost) farmers. This is of course a very restrictive assumption. However it allows us to simply represent the multi-product nature of non-food benefits by considering that the society perceives a connection “between the existence of relatively high-cost farm operations and the preservation or sustainability of rural communities” (Hueth, 2000, p. 22).

The preservation of a “large” number of relatively small family-style farms is generally viewed as more effective to the sustainability and well-being of rural communities than a “small” number of relatively large farms (European Commission, 1999; Hueth, 2000). In a more general but cumbersome framework where potential farmers have different abilities (a higher ability corresponding to lower marginal costs), any increase in the number of farms/farmers means that relatively high-cost farmers choose to enter and produce (Leathers, 1992; Guyomard et al., 2000). One can reasonably assume that the society derives non-market benefits from the production of these relatively high-cost farmers by valuing their production beyond its market value (Hueth, 2000). Under this assumption, the policy objective of an increased number of farms/farmers may be viewed as a reduced form of a more general policy objective, i.e., ensuring the fulfillment of the positive multifunctional role of agriculture. Since the same conclusions are derived from both the “general” model (farmers with different abilities) and the “simplified” model used in this paper (farmers with identical abilities), one can interpret any increase in the number of farms/farmers as an increased supply of public goods/positive externalities produced by agriculture.

The previous comparative static results provide the effects of the three policy instruments on the endogenous variables (including the number of farms/farmers) as well as on the agricultural exports. Using this comparative static results, it is also possible to determine the impact of the instruments on farmers' total profit (from programme (26)) and on yields per hectare (from equations (27) and (28a)). Details of calculations are provided in appendix 2.

Then, the comparative static effects of the three policy instruments on the four target variables are compared on an equal budget cost basis. This allows us to classify the instruments according to their ability to achieve the four considered policy objectives. For that purpose, we assume that the initial situation corresponds to the free trade equilibrium.<sup>52</sup> In other words we consider that the four income support programs are initially not in force. Such an assumption implies that the comparison of the effects of instruments on an equal budget cost basis is equivalent to a comparison on an equal total agricultural income support basis.

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<sup>52</sup> In paragraph 4.3.2, we did not specify the status of the initial market situation because derived comparative static results are valid whether the initial situation corresponds to the free trade equilibrium or not.

In a first step, we determine the differences between effects induced by each pair of instruments for the three endogenous variables and the four policy objectives related variables, for a constant budget cost/income support. Then, we examine the signs of these differences. Results of this first step are reported in Table 4.2. In a second step, the three programs are classified according to their relative ability to achieve the four considered agricultural policy objectives. Results of this second step are synthesised in Table 4.3.

#### 4.4.1. Comparison of the effects of alternative agricultural income support programs for a constant budget cost/income support

The differences between the effects induced by each pair of programs for endogenous and target variables are provided in Table 4.2.

As previously shown, when a program has an ambiguous effect on a variable, the sign of this effect is always closely related to the order of magnitude relative to one of, either  $\epsilon'_y$  (the restricted Marshallian supply elasticity of output with respect to land quantity),  $\epsilon'_r$  (the restricted Hicksian derived demand elasticity of land with respect to output level), or both. It is thus, not surprising that when the difference between the effects induced by each pair of instruments on one variable is ambiguous, its sign depends always directly on the level of one or both these elasticities relative to one.

**Table 4.2. Equal cost/support comparison of the effects of each pair of instruments on the various endogenous and target variables**

##### Panel 4.2.a. mo vs t

Differences between effects induced by pairs of instruments	Signs
$\left. \frac{dp}{dmo} \right _c - \left. \frac{dp}{dt} \right _c = -K \cdot \frac{\pi_r \pi_p (1 - \epsilon'_y)}{\det M}$	- if $\epsilon'_y \leq 1$ + if $\epsilon'_y > 1$
$\left. \frac{dr}{dmo} \right _c - \left. \frac{dr}{dt} \right _c = (K \cdot \frac{\pi_p^2 \pi_r}{\pi_r}) \cdot \frac{(1 - \epsilon'_y)}{\det M}$	- if $\epsilon'_y \leq 1$ + if $\epsilon'_y > 1$
$\left. \frac{dK}{dmo} \right _c - \left. \frac{dK}{dt} \right _c = \frac{K^2 (\pi_{pp} \pi_r - \pi_{pr}^2)}{\det M} + \frac{K (SI_r - DI_r) \pi_p \pi_{pr}}{\pi_r \det M} - \frac{K \pi_r (DD_p + DE_p)}{\det M}$	+
$\left. \frac{din}{dmo} \right _c - \left. \frac{din}{dt} \right _c = \pi_r \pi_p (1 - \epsilon'_y) \frac{-\pi_r^2 (DD_p + DE_p) + \pi_p^2 (SI_r - DI_r)}{\det M \cdot K (-\pi_r) l^2}$	+ if $\epsilon'_y \leq 1$ - if $\epsilon'_y > 1$
$\left. \frac{dPRO}{dmo} \right _c - \left. \frac{dPRO}{dt} \right _c = li \cdot \left( \left. \frac{dr}{dmo} \right _c - \left. \frac{dr}{dt} \right _c \right)$	- if $\epsilon'_y \leq 1$ + if $\epsilon'_y > 1$
$\left. \frac{dX}{dmo} \right _c - \left. \frac{dX}{dt} \right _c = DE_p \cdot \left( \left. \frac{dp}{dmo} \right _c - \left. \frac{dp}{dt} \right _c \right)$	+ if $\epsilon'_y \leq 1$ - if $\epsilon'_y > 1$

**Panel 4.2.b. mo vs sp**

Differences between effects induced by pairs of instruments	Signs
$\left. \frac{dp}{dmo} \right _c - \left. \frac{dp}{dsp} \right _c = K \cdot \frac{\pi_{pp} \cdot \pi_r^2 \cdot (1 - \varepsilon_i^y)}{\pi_p \cdot \det M}$	+ if $\varepsilon_i^y \leq 1$ - if $\varepsilon_i^y > 1$
$\left. \frac{dr}{dmo} \right _c - \left. \frac{dr}{dsp} \right _c = -K \cdot \frac{\pi_{pp} \cdot \pi_r \cdot (1 - \varepsilon_i^y)}{\det M}$	+ if $\varepsilon_i^y \leq 1$ - if $\varepsilon_i^y > 1$
$\left. \frac{dK}{dmo} \right _c - \left. \frac{dK}{dsp} \right _c = \frac{K^2(\pi_{pp} \pi_{rr} - \pi_{pr}^2)}{\det M} + \frac{K(SI_r - DI_r) \pi_{pp}}{\det M} - \frac{K \pi_{pr} \pi_r (DD_p + DE_p)}{\pi_p \det M}$	+
$\left. \frac{din}{dmo} \right _c - \left. \frac{din}{dsp} \right _c = (1 - \varepsilon_i^y) \cdot \pi_{pp} \cdot \pi_r \cdot \frac{-\pi_r^2 / \pi_p \cdot (DD_p + DE_p) + \pi_p \cdot (SI_r - DI_r)}{\det M \cdot l^2}$	- if $\varepsilon_i^y \leq 1$ + if $\varepsilon_i^y > 1$
$\left. \frac{dPRO}{dmo} \right _c - \left. \frac{dPRO}{dsp} \right _c = li \cdot \left( \left. \frac{dr}{dmo} \right _c - \left. \frac{dr}{dsp} \right _c \right)$	+ if $\varepsilon_i^y \leq 1$ - if $\varepsilon_i^y > 1$
$\left. \frac{dX}{dmo} \right _c - \left. \frac{dX}{dsp} \right _c = DE_p \cdot \left( \left. \frac{dp}{dmo} \right _c - \left. \frac{dp}{dsp} \right _c \right)$	- if $\varepsilon_i^y \leq 1$ + if $\varepsilon_i^y > 1$

**Panel 4.2.c. t vs sp**

Differences between effects induced by pairs of instruments	Signs
$\left. \frac{dp}{dt} \right _c - \left. \frac{dp}{dsp} \right _c = K \cdot \frac{\pi_{pp} \cdot \pi_r^2 + \pi_{rr} \cdot \pi_p^2 - 2 \pi_p \pi_r \pi_{pr}}{\pi_p \cdot \det M}$	+
$\left. \frac{dr}{dt} \right _c - \left. \frac{dr}{dsp} \right _c = -K \cdot \frac{\pi_{pp} \cdot \pi_r^2 + \pi_{rr} \cdot \pi_p^2 - 2 \pi_p \pi_r \pi_{pr}}{\pi_r \cdot \det M}$	+
$\left. \frac{dK}{dt} \right _c - \left. \frac{dK}{dsp} \right _c = \frac{K(SI_r - DI_r) \pi_{pp} (1 - \varepsilon_i^y)}{\det M} + \frac{K(DD_p + DE_p) \pi_{rr} (1 - \varepsilon_y^i)}{\det M}$	+ if $\varepsilon_i^y \leq 1$ and $\varepsilon_y^i > 1$ - if $\varepsilon_i^y > 1$ and $\varepsilon_y^i \leq 1$
$\left. \frac{din}{dt} \right _c - \left. \frac{din}{dsp} \right _c = \frac{((SI_r - DI_r) \pi_p^2 - (DD_p + DE_p) \pi_r^2) (\pi_{rr} \pi_p^2 + \pi_{pp} \pi_r^2 - 2 \pi_p \pi_r \pi_{pr})}{\pi_p \pi_r l^2 \det M}$	Indeterminate otherwise -
$\left. \frac{dPRO}{dt} \right _c - \left. \frac{dPRO}{dsp} \right _c = li \cdot \left( \left. \frac{dr}{dt} \right _c - \left. \frac{dr}{dsp} \right _c \right)$	+
$\left. \frac{dX}{dt} \right _c - \left. \frac{dX}{dsp} \right _c = DE_p \cdot \left( \left. \frac{dp}{dt} \right _c - \left. \frac{dp}{dsp} \right _c \right)$	-

### The decoupled subsidy with mandatory production (*mo*) vs the land subsidy (*t*)

Panel 4.2.a. shows that, for an equal budget cost, the decoupled subsidy with mandatory production leads unambiguously to a greater increase in the number of farms/farmers than the land subsidy. For all other considered variables, the signs of the differences between the impacts of both instruments depend exclusively on the level of the restricted Marshallian supply elasticity of output with respect to land quantity ( $\epsilon'_y$ ) relative to one.

If this elasticity is lower than unity, then the decoupled subsidy with mandatory production leads to a higher decrease (in absolute terms) in the price of the agricultural output than the one induced by the land subsidy. In that case, the decoupled subsidy with mandatory production leads to a greater positive trade distortion effect than the land subsidy. In the opposite case (i.e.,  $\epsilon'_y > 1$ ), the positive trade distortion effect induced by the land subsidy is always greater than the trade distortion resulting from the application of the decoupled subsidy.<sup>53</sup>

Similar results may be derived for the rental price of land and the farmers' individual profit. When the restricted Marshallian elasticity  $\epsilon'_y$  is lower than one, the increases in the rental price of land and then in the farmers' individual profit generated by the land subsidy outperform those obtained with the decoupled subsidy.<sup>54</sup> In the opposite case (i.e.,  $\epsilon'_y > 1$ ), the implementation of the decoupled subsidy leads to higher increases in both the rental price of land and the farmers' individual profit than the land subsidy.<sup>55</sup>

Finally, once again, similar conclusions arise when comparing the effects of both instruments on yields per hectare. When the restricted Marshallian elasticity  $\epsilon'_y$  is lower than one, the decrease in the level of intensification resulting from the implementation of the land subsidy outperforms the one

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<sup>53</sup> When  $\epsilon'_y > 1$ , the decoupled subsidy with mandatory production may lead either to a decrease or an increase in the price of the agricultural output. In case of a decrease, this latter will be lower (in absolute terms) than the one induced by the land subsidy. Hence, agricultural commodity exports will raise more with the land subsidy than with the decoupled subsidy. In case of an increase, exports of the agricultural commodity will decrease with the decoupled subsidy while raising with the land subsidy. Therefore, in both cases, the positive trade distortion effect resulting from the land subsidy application will be higher than the trade distortion effect (positive or negative) induced by the decoupled subsidy.

<sup>54</sup> Let's remind that the change in the rental price of land and, consequently, in the farmers' individual profit resulting from the application of the decoupled subsidy may be positive or negative. It is positive if the restricted Hicksian derived demand elasticity of land with respect to output level ( $\epsilon'_l$ ) is lower than one, and negative otherwise.

<sup>55</sup> Let's remind that  $\epsilon'_y \epsilon'_l$  is always smaller than one. Therefore, when  $\epsilon'_y$  is greater than one,  $\epsilon'_l$  is necessarily lower than one. In other words, when  $\epsilon'_y > 1$ , the decoupled subsidy leads necessarily to increase the rental price of land and, consequently, the farmers' individual profit. And these increases are greater than the ones induced by the land subsidy.

observed with the decoupled subsidy. In the opposite case (i.e.,  $\varepsilon'_y > 1$ ), the decoupled subsidy leads to a decrease in the level of intensification, decrease which is higher (in absolute terms) than the one induced by the land subsidy.

#### **The decoupled subsidy with mandatory production (*mo*) vs the production subsidy (*sp*)**

As in the previous case, Panel 4.2.b. indicates that, for an equal budget cost, the decoupled subsidy with mandatory production leads unambiguously to a greater increase in the number of farms/farmers than the production subsidy. However, for all other considered variables, the signs of the differences between the impacts of both instruments now depend exclusively on the level of the restricted Hicksian derived demand elasticity of land with respect to output quantity ( $\varepsilon'_l$ ) relative to one.

The following results apply when this elasticity is greater than unity. The decoupled subsidy necessarily leads to a decrease in the price of the agricultural output, decrease which is greater (in absolute terms) than the one induced by the production subsidy. Therefore, the decoupled subsidy generates a positive trade distortion effect that is higher than the one induced by the production subsidy. The increase in the rental price of land and then in the farmers' individual profit generated by the production subsidy is always greater than the change observed in both variables (which may be positive or negative) with the decoupled subsidy. Finally, the decoupled subsidy induces an increase in the level of intensification, increase which is greater than the one resulting from the production subsidy implementation.

One observes opposite results when the restricted Hicksian elasticity  $\varepsilon'_l$  is lower than one.

#### **The land subsidy (*t*) vs the production subsidy (*sp*)**

As shown in the previous paragraph, the land subsidy and the production subsidy both lead unambiguously to a decrease in the price of the agricultural output. However, Panel 4.2.c. suggests that, for an equal budget cost, the land subsidy induces a lower output price reduction (in absolute terms) than the production subsidy. Therefore, on an equal cost/support basis, the positive trade distortion effect generated by the land subsidy is always lower than the one resulting from the production subsidy.

In the same way, it has been shown in paragraph 4.3.2 that both instruments raise the rental price of land and, consequently, the farmers' individual profit. However, on an equal cost/support basis, the increase observed in both variables is always greater with the land subsidy than with the production subsidy.

The comparison of the impacts of the land and the production subsidies on the level of intensification is quite obvious since the former induces a decrease in yields per hectare while the latter makes this indicator to increase.

Finally, Panel 2.c. reveals that, contrary to the two previous pairs of instruments, the only ambiguous result regarding the comparison, on an equal cost/support basis, of the impacts of the land and the production subsidies relates to their relative effects on the number of farms/farmers. When the restricted Hicksian elasticity  $\varepsilon_y^h$  is lower than one while the restricted Marshallian elasticity  $\varepsilon_y^m$  is greater than one, then the increase in the number of farms/farmers induced by the land subsidy is always higher than the change observed in the same variable with the production subsidy (change which may be positive or negative). One observed the opposite situation when the restricted Hicksian elasticity  $\varepsilon_y^h$  is greater than one while the restricted Marshallian elasticity  $\varepsilon_y^m$  is lower than one. When both elasticities are lower than one, both instruments make the number of farms/ farmers to increase. But the sign of the difference between their relative impacts remains ambiguous.

#### 4.4.2. Classification of the alternative income support programs according to their ability to achieve the four policy objectives

Based on the results reported in Table 4.2, we are in a good position to classify the programs with respect to their ability to achieve policy objectives. Table 4.3 reports the obtained classification, for each of the three possible sets of conditions, with grade 1 for the most effective program and grade 3 for the worst effective one.

**Table 4.3. Ranking of equal cost/support instruments according to the four policy objectives**

Policy objectives	Decoupled subsidy <i>mo</i>	Land subsidy <i>t</i>	Production subsidy <i>sp</i>
<b>Income support</b>			
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m \leq 1$	2	1	3
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m > 1$	3	1	2
$\varepsilon_y^h > 1$ and $\varepsilon_y^m \leq 1$	1	2	3
<b>Provision of positive externalities</b>			
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m \leq 1$	1	?	?
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m > 1$	1	3	2
$\varepsilon_y^h > 1$ and $\varepsilon_y^m \leq 1$	1	2	3
<b>Reduction of negative externalities</b>			
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m \leq 1$	2	1	3
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m > 1$	3	1	2
$\varepsilon_y^h > 1$ and $\varepsilon_y^m \leq 1$	1	2	3
<b>Minimising trade distortion</b>			
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m \leq 1$	2	1	3
$\varepsilon_y^h \leq 1$ and $\varepsilon_y^m > 1$	3	1	2
$\varepsilon_y^h > 1$ and $\varepsilon_y^m \leq 1$	1	2	3

Hence, on an equal cost/support basis, the following results arise:

- i) for all possible sets of conditions on the levels relative to one of the Marshallian and Hicksian elasticities,  $\varepsilon'_y$  and  $\varepsilon'_l$ , the decoupled subsidy with mandatory production (*mo*) is the most effective instrument as regards to policy objective n° 2, i.e., under our hypotheses, for promoting the provision of positive externalities and/or public goods;
- ii) when  $\varepsilon'_y > 1$  and  $\varepsilon'_l \leq 1$ , the decoupled subsidy (*mo*) is the most effective instrument as regards to the four policy objectives. In other words, this decoupled subsidy program is the most effective instrument for simultaneously supporting agricultural income, promoting positive externalities and reducing negative externalities, while generating minimal distortion effects on trade;
- iii) for the two other sets of conditions (i.e.,  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l \leq 1$  or  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l > 1$ ), the decoupled subsidy is never the most effective instrument as regards to policy objectives n° 1, 3 and 4. It is always dominated by, at least, the land subsidy;
- iv) when  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l \leq 1$  or  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l > 1$ , the land subsidy (*l*) is the most effective program as regards to policy objectives n° 1, 3 and 4. In other words, the land subsidy is more effective than other instruments in supporting agricultural income and reducing negative externalities, while inducing minimal trade distortion effects;
- v) whatever the possible set of conditions on the levels relative to one of the Marshallian and Hicksian elasticities,  $\varepsilon'_y$  and  $\varepsilon'_l$ , the production subsidy (*sp*) is never the most effective instrument as regards to the four considered policy objectives. When  $\varepsilon'_y > 1$  and  $\varepsilon'_l \leq 1$ , it ranks last for all policy objectives. When  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l \leq 1$ , it ranks last for all policy objectives, but n° 2 (where the ranking between the land and the production subsidies is indeterminate). When  $\varepsilon'_y \leq 1$  and  $\varepsilon'_l > 1$ , the production subsidy dominates the decoupled subsidy for all policy objectives, but n° 2.

From a policy perspective, our theoretical framework allows us to state that, on an equal cost/support basis, and except specific conditions, no program uniformly dominates others for achieving simultaneously the four considered policy objectives.<sup>56</sup> In other words and in accordance with the "targeting rule", no instrument does allow to achieve effectively simultaneously several policy objectives. Thus, a government considering a specific instrument necessarily faces trade-off between

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<sup>56</sup> Specific conditions corresponds here to the case where  $\varepsilon'_y > 1$  and  $\varepsilon'_l \leq 1$ . Indeed in that case, the decoupled subsidy with mandatory production dominates both other instruments as regards to the four considered policy objectives.

objectives. In the same vein, a government pursuing different policy objectives may be well-advised to mobilise various policy instruments.

From a WTO negotiation perspective, our production subsidy program would certainly be qualified as an amber box measure while both other instruments would likely be considered as green or blue box measures. Our theoretical framework then suggests that amber-box measures are not likely to be the most effective instruments in promoting multifunctionality, provided the definition of this notion in this analysis. By way of consequence, promoting multifunctionality does not appear as an undeniable justification for claiming the continuation of amber box measures in future WTO negotiations. On the other hand, determining which green or blue box measure promotes most effectively multifunctionality while minimising trade distortion effects is not a trivial matter. This depends on conditions that cannot be predicted by theory alone. To this regards, our results put emphasis on the key role of both the restricted Marshallian supply elasticity of output with respect to land quantity and Hicksian derived demand elasticity of land with respect to output quantity.

#### **4.5. Conclusion and policy recommendations**

The objective of this chapter was to contribute to the debate on decoupling and multifunctionality issues, in relation with the current URAA green box definition. More specifically, two main questions were addressed. First, are the decoupling criteria of the green box well-designed? Second, what are the relative merits of various traditional income support policy instruments as regards to the promotion of multifunctionality?

In order to address both these questions we developed two different analytical frameworks allowing to analyse the effects of policy instruments on production and trade, the first model putting emphasis on the key role of factor mobility assumptions, the second one emphasising the key role of adjustments in the number of farmers and on the land market.

The first partial equilibrium model with two mono-product sectors using a variable input, a specific factor and a "fixed allocatable" factor reveals a suitable tool for exploring several issues relating to the decoupling of agricultural policy instruments.

Firstly, it allows us to highlight the key role of production technologies and factor mobility assumptions as regards the degree of decoupling of policy instruments. In particular, it has been pointed out that a same instrument (or a same set of instruments) may lead to very different production effects when applied in two countries characterised by different agricultural production technologies

and factor mobility situations. It has also been shown that production effects induced by a policy instrument may differ whether this instrument is applied only in one sector or in both sectors and whether this instrument is implemented alone or in conjunction with other instruments.

These concerns emphasise the need for suitable indicators of the degree of decoupling of internal support policy instruments. Such indicators would get round some drawbacks of the current WTO classification process into "boxes" where each policy measure is judged as coupled or decoupled on an absolute basis, i.e. without considering the "technological" characteristics of the targeted sector, and on an individual basis, i.e. without considering other measures used or contemplated by the countries concerned.

This model and our related analysis also highlight the key role of the factor mobility assumptions regarding the current definition of the green box direct payments to producers. In fact, one of the main results obtained with this first model is to show that the eligibility criteria of point 6 of Annex 2 of the URAA do not necessarily ensure decoupling when factor mobility is taken into account. In particular, it has been shown that when land is heterogeneous, the decoupled land-based direct payment system corresponds to a sector differentiated payment system. In that case, the decoupled system does not comply with criterion (ii) of point 6, which requires direct payments to be independent of types of production. In contrast, the uniform land-based direct payment system, conforming to criterion (ii), actually has effects on production and, consequently, is not decoupled.

This result is of major importance for future discussions on the green box definition. In this respect, one may emphasise that this result relies strongly on the extent of land heterogeneity, i.e. in our model on the magnitude of land migration parameters. Although land heterogeneity is well-admitted in agricultural production analysis, there is very little information on the extent of this heterogeneity in regions or countries. Thus, further research should be directed at providing empirical estimates of heterogeneity parameters of land (or other factors) for various countries.

Our analysis obviously relies on simplifying assumptions that future research must try to overcome (introduction of dynamics or risk, modelling of new instruments, extension of the model in order to measure the trade effects of policy instruments, etc.). Nevertheless, even with its simplified structure, our proposed framework provides valuable insights for the decoupling issue of agricultural policy instruments. A numerical application of this framework to the main WTO member countries will certainly enhance its relevance.

The second theoretical framework also suggests that in some cases the WTO green box decoupling criteria may be questioned. Indeed it has been shown that in the particular case where the land supply

and demand coming from the rest of the economy correspond to fixed amounts, the only non-zero effect of the land subsidy is to raise the rental price of land by the same amount. In this particular case, the land subsidy has no impact on the price of the agricultural product, neither on the number of farms/farmers, nor on the exports of the agricultural commodity. This result suggests that a land subsidy may be considered as a decoupled income support instrument, provided that there are restrictions on eligible land (and hence, payments) through the use on an aggregate base area. In other words, this result shows that a policy instrument that does not fully conform to all green box eligibility criteria may nevertheless has no or minimal distortion effects on trade. Therefore, from a WTO negotiation point of view, the EU could rightfully argue that the area payments in force in the EU COP sector have (at least at the aggregate level) minimal trade distortion effects (so could be considered as decoupled), although they do not fully conform to URAA decoupling criteria.

From a more general point of view, our second developed model, which allows for free entry into the agricultural sector and land price endogeneity, shows that attempts to evaluate the relative merits of various agricultural policies should take into account the impacts that these policies have on both individual producers (impact at the individual margin) and the number of producers (impact at the collective margin). For some instruments and some policy goals, impacts may be contrary to intuition or to results derived from a model with a fixed number of firms and/or an exogenous price of farmland.

Secondly, our theoretical framework allows us to state that, on an equal cost/support basis, and except specific conditions, no program uniformly dominates others for achieving simultaneously the four considered policy objectives. In other words and in accordance with the "targeting rule", no instrument does allow to achieve effectively simultaneously several policy objectives. Thus, a government considering a specific instrument necessarily faces trade-off between objectives. In the same vein, a government pursuing different policy objectives may be well-advised to mobilise various policy instruments.

Thirdly, from a WTO negotiation perspective, our production subsidy program would certainly be qualified as an amber box measure while both other instruments would likely be considered as green or blue box measures. Our theoretical framework then suggests that amber-box measures are not likely to be the most effective instruments in promoting multifunctionality, provided the definition of this notion in this analysis. By way of consequence, promoting multifunctionality does not appear as an undeniable justification for claiming the continuation of amber box measures in future WTO negotiations. On the other hand, determining which green or blue box measure promotes most effectively multifunctionality while minimising trade distortion effects is not a trivial matter.

Finally, our model allows to identify the two key parameters that have a substantial bearing on the relative effectiveness of various instruments. The next step on the research agenda will obviously be the empirical evaluation of these crucial parameters.

Many research directions represent important avenues for further study. For instance, the model is very stylized with only one output, and one single and crude indicator for negative externalities as well as for positive externalities. This is valuable for conceptual understanding of the importance of entry-exit decisions and land market characteristics, but specific policy problems should be analyzed for particular agricultural industries with more carefully specified technologies and indicators.

## APPENDIX 1

### Comparative statics of the model of paragraph 4.3.1

The system corresponding to the total differentiation of equations (3), (11), (12) and (14) is written in matrix form:

$$\begin{bmatrix} \pi_{ll}^v & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \pi_{ll}^a & 0 & -1 \\ 1 & 0 & -lo_{\lambda^v}^v & 0 & 0 & -lo_{\lambda^a}^v \\ 1 & 0 & 0 & 1 & 0 & 0 \\ \pi_{kl}^v & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \pi_{kl}^a & -1 & 0 \end{bmatrix} \begin{bmatrix} dl^v \\ d\mu^v \\ d\lambda^v \\ dl^a \\ d\mu^a \\ d\lambda^a \end{bmatrix} = \begin{bmatrix} -\pi_{lp}^v \cdot (dp^v + dsp^v) - \pi_{lw}^v \cdot (dw^v - dsv^v) - \pi_{lK}^v \cdot d\bar{K}^v - dsa^v \\ -\pi_{lp}^a \cdot (dp^a + dsp^a) - \pi_{lw}^a \cdot (dw^a - dsv^a) - \pi_{lK}^a \cdot d\bar{K}^a - dsa^a \\ 0 \\ d\bar{L} \\ -\pi_{Kp}^v \cdot (dp^v + dsp^v) - \pi_{Kw}^v \cdot (dw^v - dsv^v) - \pi_{KK}^v \cdot d\bar{K}^v - dsf^v \\ -\pi_{Kp}^a \cdot (dp^a + dsp^a) - \pi_{Kw}^a \cdot (dw^a - dsv^a) - \pi_{KK}^a \cdot d\bar{K}^a - dsf^a \end{bmatrix}$$

where:

$\pi_{ll}^j$  is negative due to the concavity assumption of the restricted profit function with respect to land,

$lo_{\lambda^v}^v$  is the positive derivative of the supply function of land type  $v$  with respect to its own price;  $lo_{\lambda^a}^v$  is the negative derivative of the supply function of land type  $v$  with respect to the price of land type  $a$ ;  $lo_{\lambda^a}^v$  differs from  $lo_{\lambda^v}^v$  in absolute value due to the homogeneity assumption of land supply functions with respect to land prices,

$\pi_{kl}^j = \pi_{lk}^j$  is a measure of the substitution relationship between land and the specific factor in production technology of sector  $j$ , which is positive if both factors are net substitutes,

$\pi_{lp}^j = \pi_{pl}^j$  and  $\pi_{Kp}^j = \pi_{pK}^j$  are marginal productivities of land and specific factors; they are assumed to be positive,

$\pi_{lw}^j = \pi_{wl}^j$  and  $\pi_{Kw}^j = \pi_{wK}^j$  are measures of substitution between the variable input and both primary factors,

$\pi_{KK}^j$  is negative due to the concavity assumption of the restricted profit function with respect to the level of the specific factor.

## APPENDIX 2

### Comparative statics of the model of paragraph 4.3.2

Total differentiation of equations (29), (30) and (32) gives:

$$(S1) \begin{bmatrix} K\pi_{pp} - DD_p - DE_p & K\pi_{pr} & \pi_p \\ K\pi_{rp} & K\pi_{rr} + Sl_r - Dl_r & \pi_r \\ -\pi_p & -\pi_r & 0 \end{bmatrix} \begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = \begin{bmatrix} -K\pi_{pp}.dsp - K\pi_{pw}.dw + K\pi_{pr}.dt \\ -K\pi_{rp}.dsp - K\pi_{rw}.dw + K\pi_{rr}.dt - d(\sum_N li) \\ \pi_p.dsp + \pi_w.dw - \pi_r.dt + dmo - dPA \end{bmatrix}$$

or, in more compact notation,

$$(S2) M \cdot \begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = \begin{bmatrix} -K\pi_{pp}.dsp - K\pi_{pw}.dw + K\pi_{pr}.dt \\ -K\pi_{rp}.dsp - K\pi_{rw}.dw + K\pi_{rr}.dt - d(\sum_N li) \\ \pi_p.dsp + \pi_w.dw - \pi_r.dt + dmo - dPA \end{bmatrix}$$

The determinant of M,  $\det M$ , is positive since it can be written as:

$$(a1) \det M = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] + (-DD_p - DE_p)(-\pi_r)^2 + (Sl_r - Dl_r)\pi_p^2 > 0$$

We now illustrate how the analysis proceeds on the example of the decoupled subsidy with mandatory production. From (S2) we immediately obtain:

$$(S3) \begin{bmatrix} dp \\ dr \\ dK \end{bmatrix} = M^{-1} \cdot \begin{bmatrix} 0 \\ 0 \\ dmo \end{bmatrix}$$

with

$$M^{-1} = (1 / \det M) \cdot \begin{bmatrix} \pi_r^2 & -\pi_r \pi_p & K \pi_{pr} \pi_r - \pi_p (K \pi_{rr} + Sl_r - Dl_r) \\ -\pi_r \pi_p & \pi_p^2 & -\pi_r (K \pi_{pp} - DD_p - DE_p) + K \pi_{pr} \pi_p \\ -K \pi_{pr} \pi_r + \pi_p (K \pi_{rr} + Sl_r - Dl_r) & \pi_r (K \pi_{pp} - DD_p - DE_p) - K \pi_p \pi_{pr} & (K \pi_{pp} - DD_p - DE_p)(K \pi_{rr} + Sl_r - Dl_r) - (K \pi_{pr})^2 \end{bmatrix}$$

Hence:

$$(a2) \det M \cdot (dp / dmo) = K \pi_{pr} \pi_r - (K \pi_{rr} + Sl_r - Dl_r) \pi_p$$

$$(a3) \det M \cdot (dr / dmo) = -(K \pi_{pp} - DD_p - DE_p) \pi_r + K \pi_{pr} \pi_p$$

$$(a4) \det M \cdot (dK / dmo) = (K \pi_{pp} - DD_p - DE_p)(K \pi_{rr} + Sl_r - Dl_r) - K^2 \pi_{pr}^2$$

These three equations may equivalently be written as:

$$(a5) \det M \cdot (dp / dmo) = -K \pi_{rr} \pi_p \left[ 1 + \frac{\pi_{pr} (-\pi_r)}{\pi_{rr} \pi_p} \right] - (Sl_r - Dl_r) \pi_p = -K \pi_{rr} \pi_p (1 - \varepsilon'_y) - (Sl_r - Dl_r) \pi_p$$

$$(a6) \det M \cdot (dr / dmo) = K \pi_{pp} (-\pi_r) \left[ 1 + \frac{\pi_{rp} \pi_p}{\pi_{pp} (-\pi_r)} \right] - (DD_p + DE_p) (-\pi_r) = K \pi_{pp} (-\pi_r) (1 - \varepsilon'_r) - (DD_p + DE_p) (-\pi_r)$$

$$(a7) \det M \cdot (dK / dmo) = K^2 (\pi_{pp} \pi_{rr} - \pi_{pr}^2) + K \pi_{pp} (Sl_r - Dl_r) - (DD_p + DE_p) (K \pi_{rr} + Sl_r - Dl_r) > 0$$

The impact of  $mo$  on  $y$  and  $l$  may be written as, respectively:

$$\begin{aligned}
 dy / dmo &= \pi_{pp} \cdot (dp / dmo) + \pi_{pr} \cdot (dr / dmo) \\
 \text{(a8)} \quad &= (1 / \det M) [\pi_{pp} [K\pi_{pr}\pi_r - (K\pi_{rr} + Sl_r - Dl_r)\pi_p] + \pi_{pr} [-(K\pi_{pp} - DD_p - DE_p)\pi_r + K\pi_{rp}\pi_p]] \\
 &= (1 / \det M) [-K(\pi_{pp}\pi_{rr} - \pi_{pr}\pi_{rp})\pi_p - \pi_{pp}(Sl_r - Dl_r)\pi_p + \pi_{pr}(-DD_p - DE_p)(-\pi_r)] < 0
 \end{aligned}$$

$$\begin{aligned}
 dl / dmo &= -\pi_{rp} \cdot (dp / dmo) - \pi_{rr} \cdot (dr / dmo) \\
 \text{(a9)} \quad &= (1 / \det M) [-\pi_{rp} [K\pi_{pr}\pi_r - (K\pi_{rr} + Sl_r - Dl_r)\pi_p] - \pi_{rr} [-(K\pi_{pp} - DD_p - DE_p)\pi_r + K\pi_{rp}\pi_p]] \\
 &= (1 / \det M) [-K(\pi_{pp}\pi_{rr} - \pi_{rp}\pi_{pr})(-\pi_r) + \pi_{rp}(Sl_r - Dl_r)\pi_p - \pi_{rr}(-DD_p - DE_p)(-\pi_r)] < 0
 \end{aligned}$$

From (a8) and (a9), we readily derive the impact of  $mo$  on intensification  $in$  (yields per hectare):

$$\begin{aligned}
 l^2 \cdot (din / dmo) &= (dy / dmo)l - (dl / dmo) \cdot y \\
 \text{(a10)} \quad &= (1 / \det M) [(Sl_r - Dl_r)(-\pi_p) [\pi_{pp}(-\pi_r) + \pi_{rp}\pi_p] + (-DD_p - DE_p)(-\pi_r) [\pi_{pr}(-\pi_r) + \pi_{rr}\pi_p]] \\
 &= (1 / \det M) [(Sl_r - Dl_r)(-\pi_p)\pi_{pp}(-\pi_r)(1 - \epsilon'_i) + (-DD_p - DE_p)(-\pi_r)\pi_{rr}\pi_p(1 - \epsilon'_j)]
 \end{aligned}$$

Finally, the impact of  $mo$  on farmers' individual profit may be written as:

$$\text{(a11)} \quad dPRO / dmo = \pi_p \cdot (dp / dmo) + \pi_r \cdot (dr / dmo) + li \cdot (dr / dmo) + 1 = li \cdot (dr / dmo)$$

Proceeding similarly for the land subsidy ( $t$ ) and the production subsidy ( $sp$ ) yields the following comparative static results:

$$\text{(a12)} \quad \det M \cdot (dp / dt) = -(Sl_r - Dl_r)\pi_p(-\pi_r) < 0$$

$$\text{(a13)} \quad \det M \cdot (dr / dt) = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] - (DD_p + DE_p)(-\pi_r)^2 > 0$$

$$\text{(a14)} \quad \det M \cdot (dK / dt) = (Sl_r - Dl_r)[K\pi_{pp}(-\pi_r)(1 - \epsilon'_i) - (DD_p + DE_p)(-\pi_r)]$$

$$\text{(a15)} \quad l^2 \cdot \det M \cdot (din / dt) = -(Sl_r - Dl_r)\pi_p[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] < 0$$

$$(a16) \quad dPRO / dt = li.(dr / dt) > 0$$

and

$$(a17) \quad \det M.(dp / dt) = -(Sl_r - Dl_r)\pi_p(-\pi_r) < 0$$

$$(a18) \quad \det M.(dr / dt) = K[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] - (DD_p + DE_p)(-\pi_r)^2 > 0$$

$$(a19) \quad \det M.(dK / dt) = (Sl_r - Dl_r)[K\pi_{pp}(-\pi_r)(1 - \varepsilon_l^y) - (DD_p + DE_p)(-\pi_r)]$$

$$(a20) \quad l^2 \cdot \det M.(din / dt) = -(Sl_r - Dl_r)\pi_p[\pi_{rr}\pi_p^2 + \pi_{pp}(-\pi_r)^2 + 2\pi_{pr}\pi_p(-\pi_r)] < 0$$

$$(a21) \quad dPRO / dt = li.(dr / dt) > 0$$

## **5 - ASSESSING THE DEVELOPMENT OF THE WORLD MARKET ENVIRONMENT**

### **Simulating the impact of further trade liberalisation on world agricultural markets using the WATSIM model**

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#### **5.1. Introduction**

The objective of this part of the project (i.e., subtask 1.3) was to revise and update the World Agricultural Trade Simulation (WATSIM) Modelling System, in order to allow for a comprehensive analysis of issues arising with the ongoing multilateral negotiations on trade in agricultural commodities. The overall task can be broadly divided in three main directions of work, namely the update and extension of the WATSIM Data Base, further developments in the WATSIM simulation model, and applications in the context of the current negotiations.

The Data Base has been updated to now include time series up to 1997, with additional data for 1998 and 1999. More important, however, seems the complementation of the existing Non-Spatial Data Base by a completely new Spatial Data Base, comprising full and consistent trade flow matrices for all commodities and regions considered by the simulation model.

The simulation model itself was revised with respect to two main areas. On the one hand, its original representation of net trade developments has been changed to now endogenously consider gross imports and exports on the same market. On the other hand, and based on the gross trade approach, the model's representation of tariff barriers and export subsidies has been improved. Moreover, tariff rate quotas that have become relevant particularly after the Uruguay Round Agreement on Agriculture, are now explicitly modelled.

Finally, the model was applied for three types of analysis: First, a baseline or reference run was performed to picture the likely medium term outlook for regional and international agricultural commodity markets. Second, the question about to what degree policy measures like the EU CAP compensatory payments are coupled to or decoupled from agricultural production, is important to reflect in the model. Even though the answer on this question cannot be found within WATSIM, alternative assumptions on the degree of decoupling of EU area and headage payments were considered with respect to the impact on EU and global markets. Third, based on the experience of the Uruguay Round Agreement on Agriculture, a stylised liberalisation scenario was simulated to analyse the possible impact of a future WTO agreement.

This chapter is organised as follows. Section 2 describes the WATSIM Data Base, with a special focus on the new developments with respect to the new Spatial Data Base. Section 3 presents the simulation model, with a particular attention paid on the representation of gross trade and of policy measures. The following section 4 presents and discusses the main assumptions and the outcome of the reference run, picturing likely developments of regional and international markets until 2010. Then, section 5 focuses on the results of some alternative simulations performed with the model. Section 6 finally summarises the main findings and brings some concluding remarks.

## 5.2. The WATSIM Modelling system: The WATSIM Data Base

A solid, comprehensive and consistent data base is required for a sound understanding of past developments as well as current situation on agricultural markets. In addition to that, the data base serves as the basis for projections of future market developments, which in turn are the reference for possible alternative policy scenarios. Thus, the WATSIM Data Base has been updated and now consists of two parts, namely the Non-Spatial Data Base (NSDB), and the Spatial Data Base (SDB). The general concept of the WATSIM Data Base can be summarised by the following criteria:

- *Long time series.* Most time series in the NSDB now include the period 1961 to 1997, with some series extending to 1999. Time Series in the new SDB comprise the years 1988 to 1997.
- *Regional differentiation.* The principal data are available at the single country level (NSDB only).
- *Product differentiation.* Time series on supply and utilisation are incorporated for a set of some 110 agricultural commodities and hence in much more details than needed for the simulation model itself (NSDB only).
- *Consistency.* Regional data provide full consistency, i.e. market balances, processing coefficients, etc are checked.
- *Flexibility.* Both on the regional and the product side, flexible aggregation tools allow for adjustment of aggregation levels to the user's (and modeller's) needs (NSDB only).
- *Easy and quick access.* The technical realisation of the WATSIM Data Base allows for an easy and efficient access to the large amount of data, both for the user and the model's programming routines.

The WATSIM Data Base now consists of two sub-sets. Based on the existing system<sup>57</sup>, the WATSIM Non-Spatial Data Base (NSDB) has been updated and redesigned for the purposes of this project. Additionally, the WATSIM Spatial Data Base (SDB) has been newly developed to incorporate

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<sup>57</sup> See von Lampe (1999).

bilateral trade flows and prices across the model's regions. In this section, both the NSDB and the SDB are outlined in their construction and content, with a particular focus on the improvements and further developments as compared to the former data base.

### *5.2.1. The WATSIM non-Spatial Data Base*

#### *5.2.1.1. Data sources*

The WATSIM NSDB has been designed already for the former version of the system. It brings together data from various sources on production, demand and trade of agricultural commodities, macroeconomic and sectoral data, as well as policy data. Specifically, the WATSIM NSDB is fed by the following sources<sup>58</sup>:

- *FAOSTAT*. The FTP-accessible (license needed) data base of the Food and Agriculture Organisation of the UN provides supply, demand, stock and trade data for several hundred commodities at the single country level. In addition, prices and nutrient consumption figures are included. On the macroeconomic side, irrigation data are used, while population data are generally taken from the UN statistics. Time series comprise the years 1961 to 1997, partly up to 1999.

- *Production, Supply and Distribution (PS&D)*. The freely web-accessible data base of the United States Department of Agriculture also provides supply, demand, stock and trade data for some 60 products and product aggregates, again at the single country level. Data are generally less detailed with respect to the demand structure, but comprise the years 1961 to 1999.

- *World Development Indicators*. Most macroeconomic data are taken from the World Bank's data base on CD-Rom, such as figures on GDP and inflation. Time series comprise the years 1960 to 1998, albeit some of them are incomplete.

- *World Population Prospects*. The UN estimations on urban, rural and total population not only provide ex-post time series from 1960 to 1997, but also projection until 2050.

- *Producer and Consumer Support Estimates (PSE/CSE Data Base)*. The data base of the Organisation for Economic Co-operation and Development represents the main source for agricultural policies and is also important in terms of domestic and international prices.

Various other sources are used to obtain price and income elasticities, prices, feed parameters and policy data.

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<sup>58</sup> The years given for the time series refer to the time of download for the current version of the WATSIM Data Base. At the time of writing this report, most sources provide more recent data than stated here.

### *5.2.1.2. Data processing*

Data from all sources were updated such that the current base year for model simulations now is 1997. Data from the different sources are merged, with a clearly defined list of priority if figures with the same content are provided by more than one source. For example, commodity balance data are generally taken from FAOSTAT, supplemented by PS&D data in cases where FAO data are missing. Similarly, population data are generally taken from the UN, but may be supplemented by FAO data in case. Of course, where different sources are merged, data are not simply copied, but in general growth rates are used rather than absolute figures.

A consistency routine is then run across all data sets, to ensure balanced supply and utilisation accounts, consistent net trade figures, and realistic processing and yield coefficients. Eventually, aggregation routines yield data sets for the regional and commodity aggregates used in the simulation model (see below for details).

### *5.2.2. The WATSIM Spatial Data Base*

In contrast to the NSDB, the WATSIM SDB represents a completely new and unique data base developed during the last three years. The need for the representation of bilateral trade flows resulted from the aim to consider gross trade rather than net trade in the simulation model. Due to the fact that the model works on an aggregated regional level, gross imports and exports for individual countries reported by both FAOSTAT and PS&D cannot be used for the model itself.<sup>59</sup> To calculate gross trade figures for regional aggregates, bilateral trade flows across individual countries are therefore necessary.

#### *5.2.2.1. Data sources*

In principle, there are four sources available for bilateral trade flows on agricultural markets, including:

- *COMEXT*. COMEXT is the official data base on external trade statistics of the European Union (EU) and on internal trade across EU member countries. COMEXT comprises bilateral trade between the EU and its trade partners, but excludes trade between non-EU regions and countries. It is therefore not suitable for the construction of global trade matrices.

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<sup>59</sup> The sum of gross imports of all countries within a region does not necessarily (and in fact, will only by chance) equal the gross import of the regional aggregate, due to intra trade that cannot be distinguished from extra trade.

- *FATUS*. Similar to COMEXT, FATUS represents the foreign trade statistics data base of the United States, containing trade flows (imports and exports) between the US and its trade partners. Again, trade flows between non-US regions and countries are not considered, making FATUS alone unsuited for the construction of global trade matrices.
- *TRAINS*. The TRAINS data base is developed by the United Nations Conference on Trade and Development (UNCTAD) and contains import data across a broad number of countries. In fact, TRAINS represents a subset of the under-mentioned COMTRADE data base and was therefore, after thorough examination, excluded from the further consideration in the WATSIM SDB.
- *COMTRADE*. The *Commodity Trade Data Base*, developed and maintained by the United Nations Statistics Division, comprises both import and export quotations by origin and destination for more than 100 countries and a wide set of agricultural and non-agricultural commodities, with time series extending from 1988 to 1998. While in this project, both COMEXT and FATUS were basically excluded from consideration in the SDB because of their regional limitations<sup>60</sup>, COMTRADE represents the main source for bilateral trade flows. Möllmann (forthcoming) uses FATUS data to check the WATSIM SDB with respect to its plausibility.

The WATSIM team did not have direct access to the COMTRADE data. Instead, staff of the EU Commission's Directorate General Agriculture (DG-Agri) assisted by providing regionally aggregated trade flows for further processing by the WATSIM team. With respect to the product aggregation, significant difficulties had to be solved due to the high degree of product differentiation in COMTRADE (Harmonised Commodity Description and Coding System, HS 96) and in WATSIM (aggregated basically from the Standard International Trade Classification, SITC, used by FAOSTAT). In particular, conversion rates applying for the processing of raw products to derived commodities were used. Table 5.1 shows the commodity representation in the different data bases as well as the applied conversion rates for the example of wheat.

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<sup>60</sup> One could, however, use both COMEXT and FATUS in addition to COMTRADE in order to improve the data base, an effort that was left for future projects.

**Table 5.1. Commodity representation of wheat in WATSIM, FAOSTAT and COMTRADE**

WATSIM CONB	WATSIM CONC	Aggregate	FAO Element Code	Conversion factor	Elements in aggregate	FAOSTAT Code (SITC Rev.2)	Conversion factor	COMTRADE HS 96
WHEAT	WHEAT	WHEAT & PRODUCTS	2511	1.0000	WHEAT	15	1.0	1001
				1.3889	FLOUR WHEAT	16	1.0	1101;1103.11,21
				1.3889	MACARONI	18	1.0	1902.11,19
				1.1574	BREAD	20	1.0	1905.10,40
				1.0526	BULGUR	21	1.0	1104.29ex
				1.3889	PASTRY	22	1.0	1905.20,30,90ex
				1.6340	WHEAT,STARCH	23	1.0	1108.11
				1.0000	BREAKFAST CEREALS	41	1.0	1904

Source: FAOSTAT (1999), WATSIM Data Base

#### 5.2.2.2. Consistency adjustment

A major task in the construction of the Spatial Data Base was to ensure full consistency both within the SDB and compared to the NSDB. Given that statistics on bilateral trade flows generally come from two different sources, i.e. the quoting importer and the quoting exporter, the same trade flow is described by two figures within the original data base. Experiences show that this “double reporting” does not necessarily yield in mutual confirmation, but may lead to significant contradictions within the data base. Clearly, these inconsistencies cannot be satisfactory in a useful data base, and may result in significant problems with respect to the simulation model that is based on such data. Problems and inconsistencies include the following phenomena:

- *Lack of data.* Some of the trade flows are not reported at all by either importers or exporters, or both. In some cases, these problems arise in regions with traditional trade across open borders (e.g. beef trade within West Africa, see von Kirchbach, 1991).
- *Inconsistencies of import and export quotations.* In many cases, bilateral trade flows are reported with significant discrepancies between the reporting importer and its exporting counterpart.
- *Inconsistencies of total trade compared to a region's net trade.* The sum of all exports, net of the sum of all imports reported of a given country or region, should equal the region's net trade that is available from other (official) statistics, if these are credible. This, however, often is not the case. In some extreme cases, for a region with significant net exports or net imports, no exports or imports are reported at all.
- *Unit problems.* In some cases, inconsistencies appear to result from the use of incorrect quantity or value units (e.g., 1000 tonnes instead of 1 tonne).
- *Reliability.* Often, trade flows are more accurately documented by the importer than by the respective exporter, given that many countries rigorously control imports, but put less emphasis on exports. Similarly, industrialised countries tend to report their trade more accurately than developing countries.

Before we will focus on the methodology applied to calculate consistent trade flow matrices for the WATSIM SDB, another approach used for the Global Trade Analysis Project (GTAP, see Gelhar, 1996) will be presented and briefly discussed. This approach is generally based on the assumption that, for each trade flow reported by one exporter and one importer, only one of the two figures provides proper information on the actual trade flow. Since, however, one cannot argue that a certain country has perfect quotation for all markets, the decision which figure has the highest priority has to be made for each market individually, based on the *Index of Reliability*.<sup>61</sup> For this index, the level of consistency is calculated in a first step for each trade flow and the respective export and import quotations, by dividing the absolute difference between reported import and export by the import quotation. For a given country and a given market, the index of reliability of imports is then calculated as the sum of imports in trade flows with a consistency level better than a given threshold, divided by the sum of all imports of that region, with each of the sums taken over the available partner (i.e., exporting) regions. Similarly, the index of reliability of exports takes the sum of exports in trade flows with a consistency level better than a given threshold, divided by the sum of all exports of that region. For each region and each commodity, this procedure will therefore yield one index of reliability on the import side, and one on the export side. For the threshold applied to distinguish between acceptable and unacceptable discrepancies between import and export quotation, a margin of 20% is used.

For the construction of the consistent trade flow matrix, the exporter's index of reliability of exports is compared to the importer's index of reliability of imports for each trade flow. The figure reported by the country with the lower index is dropped, and the figure provided by the country with the larger index is used and taken as the true figure.

While this approach has the advantage that it works without any generalisation, in that each trade flow is checked individually and no trading region is "condemned wholesale" for any reason, the described procedure has three major disadvantages for the construction of the WATSIM SDB:

- *Missing consistency with the WATSIM NSDB*. The index of reliability based approach provides trade matrices that are internally consistent. However, it cannot assure that resulting trade flow match the net trade positions given by other sources, such as the WATSIM Non Spatial Data Base.

- *Loss of information*. Given that the data provided by the "less reliable" trade partner is dropped, it is implicitly assumed that the informational content of those data is nil, while full trust is given to the respective partner country. One can expect, however, that even the "more reliable" country might make inaccurate quotations, while the "less reliable" country may still provide some information.

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<sup>61</sup> At this point, we ignore the fact that GTAP works with values only, a fact that implies further complications in that fob- and cif-based volumes need to be converted to uniform fob volumes. See Gelhar, 1996, for details.

- *Arbitrary choice of the threshold value.* The fixed threshold value at 20% is arbitrarily chosen, but may have significant impacts on the outcome. Since the use of this threshold makes reliability a zero-one decision, no difference is made between equal quotations and trade flows, where discrepancies between import and export figure are just below those 20%, while the impact of the discrepancy being 19% or 21% is immense. Another threshold value, say 25%, might therefore completely change the order of reliability across regions.

For the construction of the WATSIM SDB, another approach is used, based on the assumptions that:

- All available data is useful to provide some information, where the informational content depends on the market and the reporting region.
- The net trade data available in the WATSIM-NSDB is taken as right-hand side values, i.e. they are assumed to be correct.
- We do not want to add any information that we do not actually have.

We therefore employed an entropy-based approach.<sup>62</sup> The principal assumption of this approach is that each data point in fact is a stochastic variable with a certain mean, a certain range of possible values, and a specific probability distribution within this range. While the Maximum Entropy (ME) approach starts with an equipartition of probabilities within the given range, the Cross Entropy (CE) approach explicitly allows for a priori information on the probability distribution. A general formulation of the CE approach is given by the following problem:

$$\max C(p) = - \sum_{i,r,r',t,k} p_{i,r,r',t,k} \ln \left( \frac{p_{i,r,r',t,k}}{q_{i,r,r',t,k}} \right) = - \sum_{i,r,r',t,k} p_{i,r,r',t,k} \ln(p_{i,r,r',t,k}) + \sum_{i,r,r',t,k} p_{i,r,r',t,k} \ln(q_{i,r,r',t,k})$$

*s.t.*

- (a)  $\sum_k p_{i,r,r',t,k} = 1$
- (b)  $\sum_k p_{i,r,r',imp,k} * SP_{i,r,r',imp,k} = IMP_{i,r,r'}$
- (c)  $\sum_k p_{i,r,r',exp,k} * SP_{i,r,r',exp,k} = EXP_{i,r,r'}$  (1)
- (d)  $EXP_{i,r,r'} = IMP_{i,r',r} * XCORR_i$
- (e)  $\sum_{r'} EXP_{i,r,r'} - \sum_{r'} IMP_{i,r,r'} = NETP_{i,r}^{NSDB}$
- (f)  $\sum_{r'} IMP_{i,r,r'} = / \leq PIMP_{i,r}^{NSDB}$
- (g)  $\sum_{r'} EXP_{i,r,r'} = / \leq PEXP_{i,r}^{NSDB}$

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<sup>62</sup> See Golan, Judge and Miller, 1996.

where:	C(p)	Cross entropy objective variable
	p	Probability of support point k
	q	A priori probability of support point k
	SP	Support point
	IMP	Calibrated import flow
	EXP	Calibrated export flow
	XCORR	Correction factor for global market (see text)
	NETP <sup>NSDB</sup>	Net trade data from non-spatial data base
	PIMP <sup>NSDB</sup>	Gross import data from non-spatial data base
	PEXP <sup>NSDB</sup>	Gross export data from non-spatial data base
	i	Product index
	r,r'	Region index
	t	Trade flow type index, $t \in \{\text{imp}, \text{exp}\}$
	k	Support point index

The relevant optimisation constraints can be interpreted as follows:

- (a). Probabilities for each import or export flow must sum up to unity.
- (b). The import flow is the sum of the import support points, weighted by the probabilities associated to them.
- (c). The export flow is the sum of the export support points, weighted by the probabilities associated to them.
- (d). The export of commodity i by the reporting region r to trade partner r' must be equal to the import of that commodity by the reporting region r' from the trade partner r, adjusted only by a global, market specific correction factor. This correction factor results from the fact that the NSDB itself is not fully consistent in that total net exports are not exactly equal to total net imports, and assures that the balance in the trade flow matrix is the same as in the non-spatial data.
- (e). Total gross exports, net of total gross imports, of a reporting region r, must be equal to the net trade of that region documented in the NSDB.
- (f). In the case of single countries, total gross imports of a reporting country r must equal the gross imports of that country documented in the NSDB. In the case of regional aggregates, total gross imports must not exceed the NSDB imports (which are the simple sum of imports of the aggregate's member countries and may include intra-trade).

(g). In the case of single countries, total gross exports of a reporting country  $r$  must equal the gross exports of that country documented in the NSDB. In the case of regional aggregates, total gross exports must not exceed the NSDB exports (which are the simple sum of exports of the aggregate's member countries and may include intra-trade).

Four support points are defined for each import quantity and each export quantity such that:

- First, both the inner two and the outer two support points are centred around the reported quantity, respectively.
- Second, the distance of the inner two support points positively relates to the relative deviation of the import and export quotation of the respective trade flow (i.e., on the reliability of the quotations of this trade flow).
- Third, the outer two support points are chosen far away from the quoted data in order to ensure solvability even if the quoted gross trade figures have little to do with each other and with the net (aggregates) or gross (individual countries) trade figures taken from the NSDB.

By assigning large a priori probabilities (i.e., 0.49 respectively) to the inner support points, and small ones (0.01, respectively) to the outer support points, the model ensures that the inner supports (and hence, the reliability of the trade quotations) are relevant for the results whenever solvability allows for this, while breaking out towards one of the outer supports forces to significantly worsen the objective function, since the relative increase of the respective probability then needs to be very large.

Generally, trade prices in contrast to trade quantities are not subject of calibration, but are only checked for plausibility. Prices are mechanistically considered to be implausible if they are more than twice as high, or less than half as high, as the average model's world market price on that market, and are therefore dropped. Missing (or dropped) prices are recalculated according to the following list of priorities:

- If the price of the respective trade partner is available, and both prices for that trade flow exist in other years, the relative price difference between the partners is used to calculate the missing price.
- If this is not possible, but prices for comparable commodities are available for the respective year, the relative price difference on those markets is used.

If this is not possible either, but prices for comparable commodities are available for other years, the relative price difference in these years is used.

- If this is not possible either, but prices for the given trade activity exist for other years, the relative change of the model's world market price is used.

- Finally, if no prices are available for the given trade activity at all, the model's world market price itself is applied.

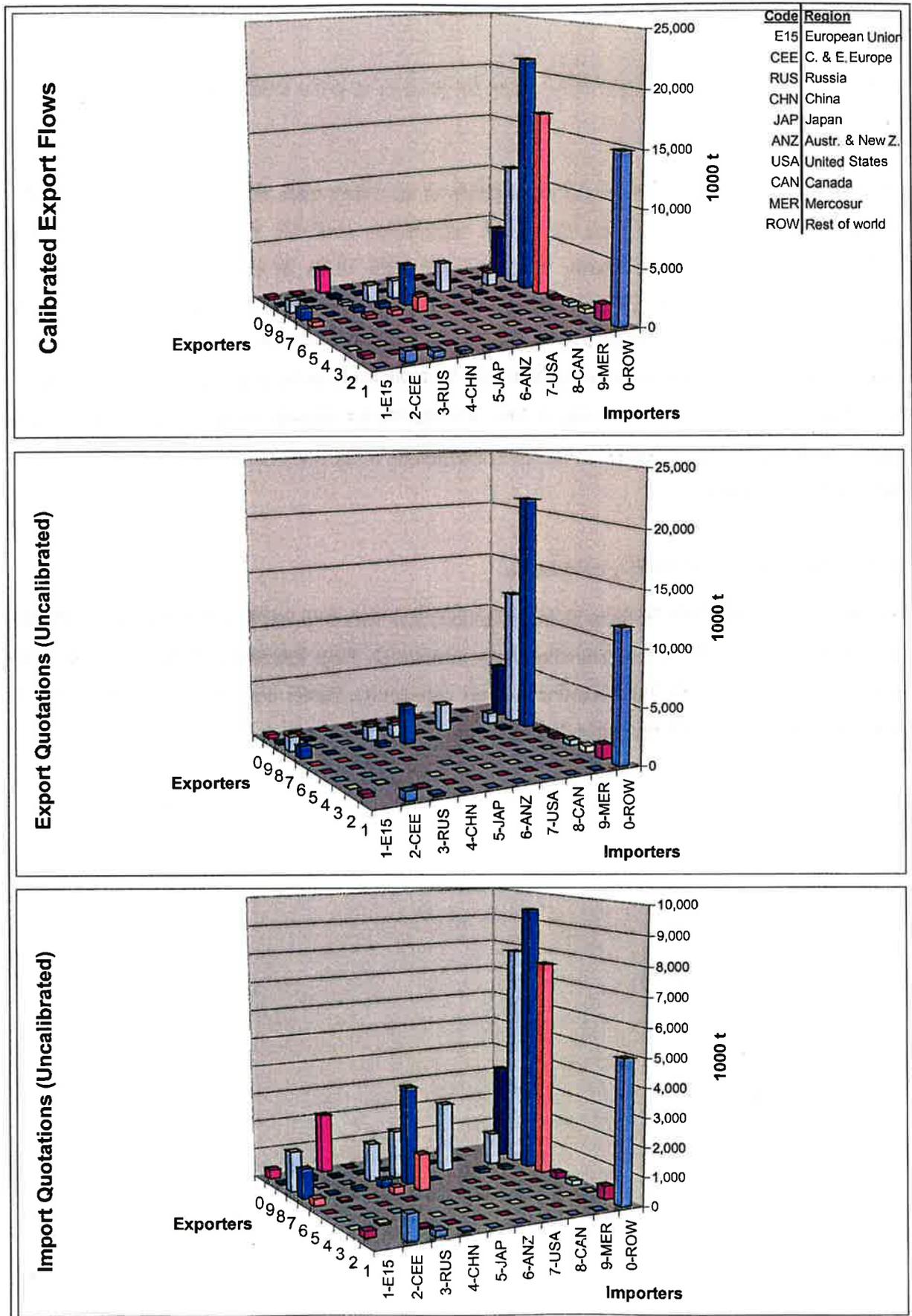
Values are then recalculated by simply taking the product of price times quantities for imports and exports.

The described approach allows for the construction of consistent trade matrices, matching to the data provided by the NSDB. It makes use of all information available without imposing additional assumptions that are not necessarily valid, weighting the value of each figure by the level of correspondence between the reported exports and imports, respectively, which, in contrast to the above-mentioned index of reliability, is a continuous function rather than a zero-one decision. The disadvantage of the procedure, the fact that in case of implausible quotations basically all trade figures are adjusted to some degree resulting in that few figures are exactly equal to those found in the original statistics, is closely related to the main assumption of the approach that each figure contains at least some information.

#### *5.2.2.3. Results of the consistency calculation*

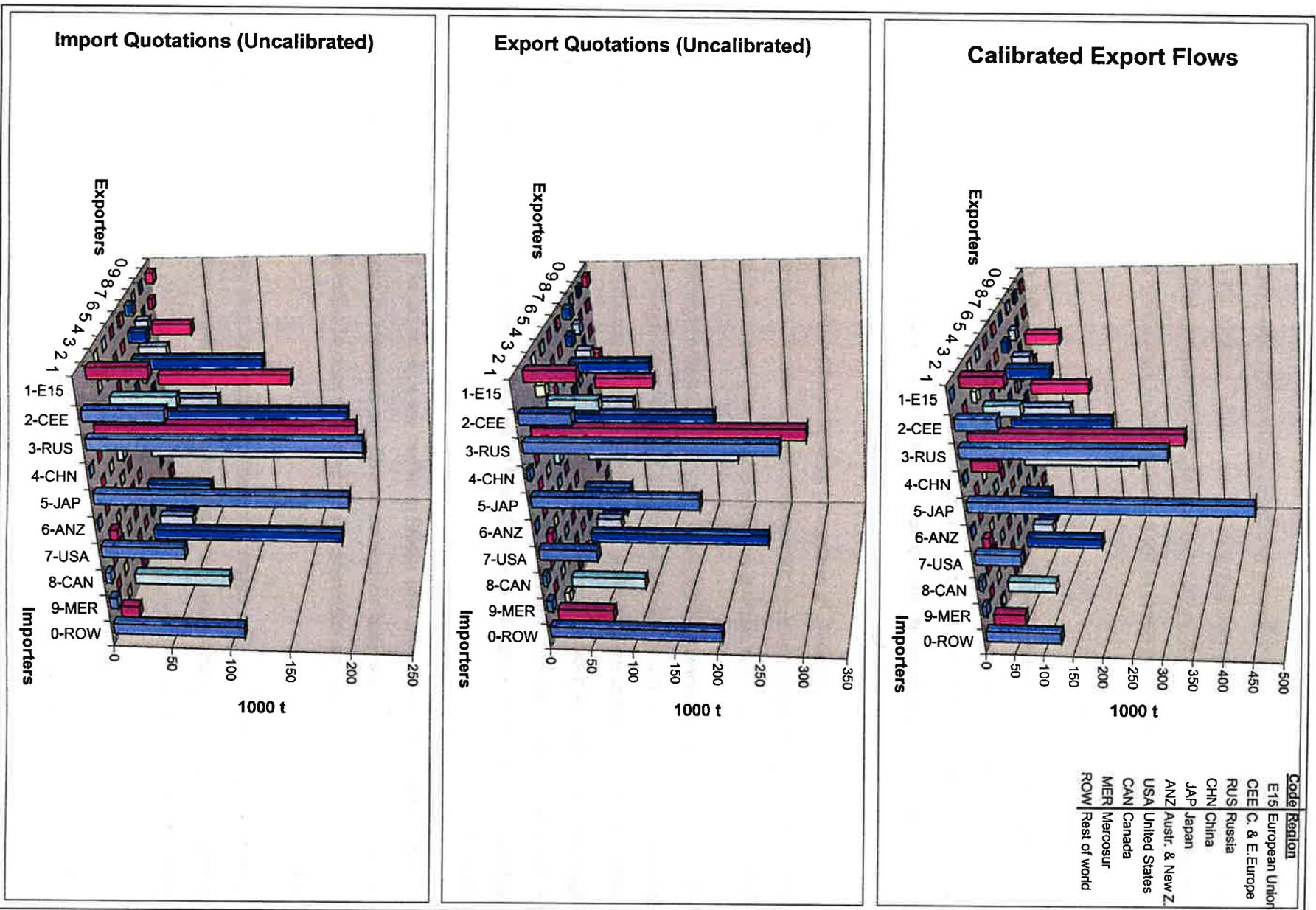
Generally, more recent data seem to be more accurate than data from earlier years. Figure 5.1 presents the calibration results for wheat, showing the comparatively large discrepancies between export and import quotations even for this well-documented commodity. Better consistency was found for the base year's pigmeat markets as shown by Figure 5.2.

Figure 5.1. Results of the consistency calibration process for wheat, 1997



Source: COMTRADE Data Base, own calculations

Figure 5.2. Results of the consistency calibration process for pigmeat, 1997



Source: COMTRADE Data Base, own calculations

### 5.3. The WATSIM modelling system: The simulation model

This section focuses on the description of the WATSIM modelling system by first briefly outline the overall concept of the model, referring to existing publications wherever applicable. Emphasis is then put on the two main recent developments of the model, namely the shift from a pure net trade representation to a gross trade model that considers both imports and exports on the same market simultaneously, and the enlargement of the representation of agricultural policy measures.

#### 5.3.1. Overall concept<sup>63</sup>

The World Agricultural Trade Simulation Model (WATSIM) is the result of a development that started with the SPEL-Trade Model in the late 1980s. The system, as it stands today, was developed in order to comply with the needs for a policy simulation tool for the preparation of the current multilateral trade negotiations in the context of the World Trade Organisation (WTO). It can be broadly characterised as follows:

- *Partial equilibrium framework.* In contrast to general equilibrium models, WATSIM only covers a part of the whole economy, namely the markets for agricultural commodities. Developments in the overall economy and on other markets are taken exogenously or are neglected.
- *Multi-region, multi-commodity framework.* The current version represents 10 countries and regional aggregates, representing the whole world (Figure 5.3). For each region as well as on the global level, markets for 29 agricultural commodities are included, covering cereals (5 products); starchy products; sugar; pulses; oilseeds (4 products); vegetable oils (4 products); vegetable oil cakes (4 products); meat (4 products); eggs; milk; and milk products (3 products). Both the regional and the commodity aggregation level can, however, be easily adjusted to the user's needs within the data base (see above, section 5.2).
- *Comparative static framework.* The model is solved for a given set of target years, results of which can be compared to the base year's situation or with the outcomes of other simulations. In contrast to dynamic models, however, no information is given on the path of adjustment between base and target years.
- *Deterministic framework.* The model disregards all kinds of risk and uncertainty, and assumes "average" conditions, though issues like weather and other stochastic variables may well be important for the agricultural markets.

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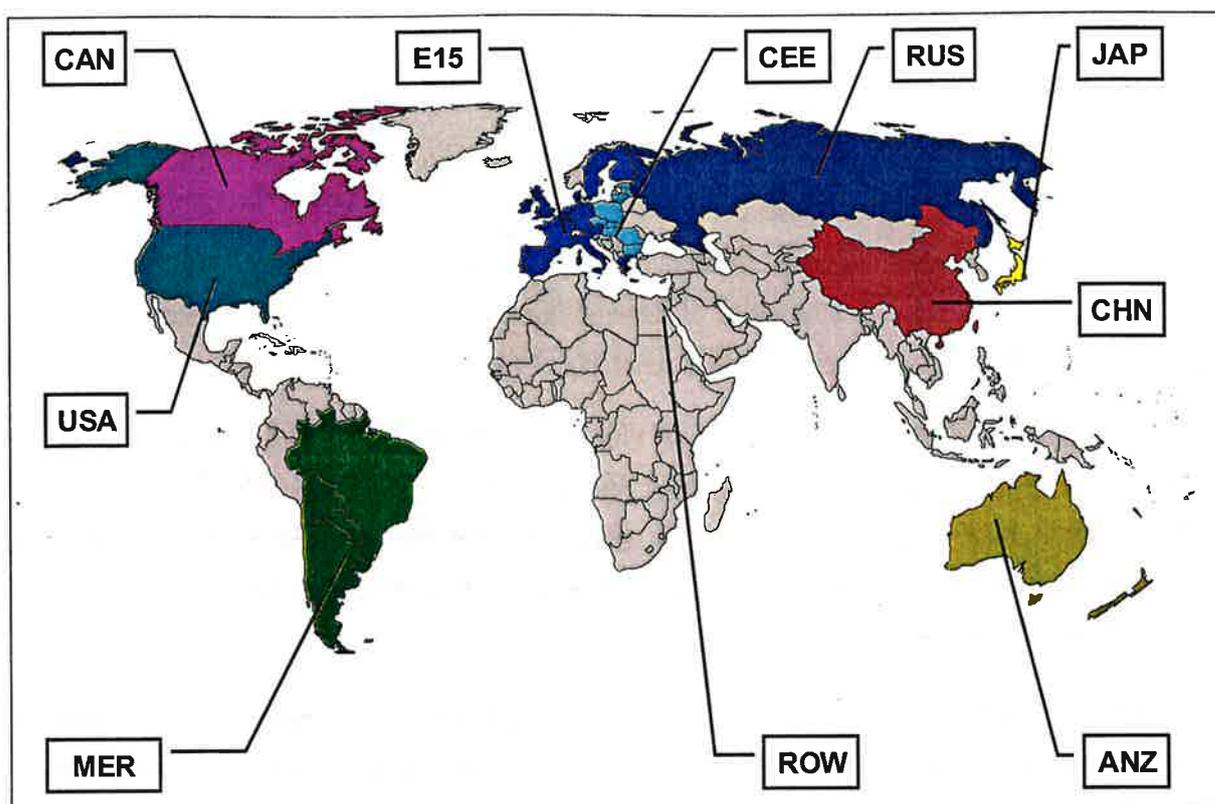
<sup>63</sup> A more detailed discussion on the modelling concept of WATSIM can be found in von Lampe (1999).

- *Non-spatial framework.* World markets for all commodities are assumed to be spot markets, with no differentiation of bilateral trade flows. Traded commodities are, however, differentiated from domestic sales by both producers and consumers (see paragraph 5.2.2 for details on the gross trade approach).
- *Synthetic framework.* Most parameters used to describe supply and demand behaviours are not estimated within the WATSIM system, but borrowed from other models or literature. Exceptions include, however, feed requirement parameters (i.e., feed energy use per unit of livestock production) and the adjustment of income elasticities of demand due to economic growth. Of course, all price elasticities are subject to careful calibration to meet microeconomic theory.<sup>64</sup>
- *Consideration of key shift variables for supply and demand.* Both medium and long term projections of supply and demand are improved by taking into account the underlying shift factors, including population and income growth, urbanisation, expansion and reduction of availability of land, irrigation, and feed efficiency. Technical progress is assumed to follow its longer term – though not necessarily linear – trend.
- *Consideration of key policy variables.* By explicitly modelling the most important policy measures, policy relevant simulations are possible as they are necessary, for example in the context of the current multilateral negotiations on further trade liberalisation. Instead of using simple price wedges between domestic and foreign trade prices, WATSIM distinguishes between specific and ad-valorem tariffs and variable levies on the import side. Additionally, the model explicitly considers tariff-rate quotas. On the export side, export subsidies are modelled in combination with limits on subsidised exports resulting from the URAA. Domestic support is differentiated in product-related subsidies and factor-related payments (area payments, headage premiums). See section 5.2.3 for details on the modelling of policy measures.

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<sup>64</sup> See von Lampe (1999), p. 53 f.

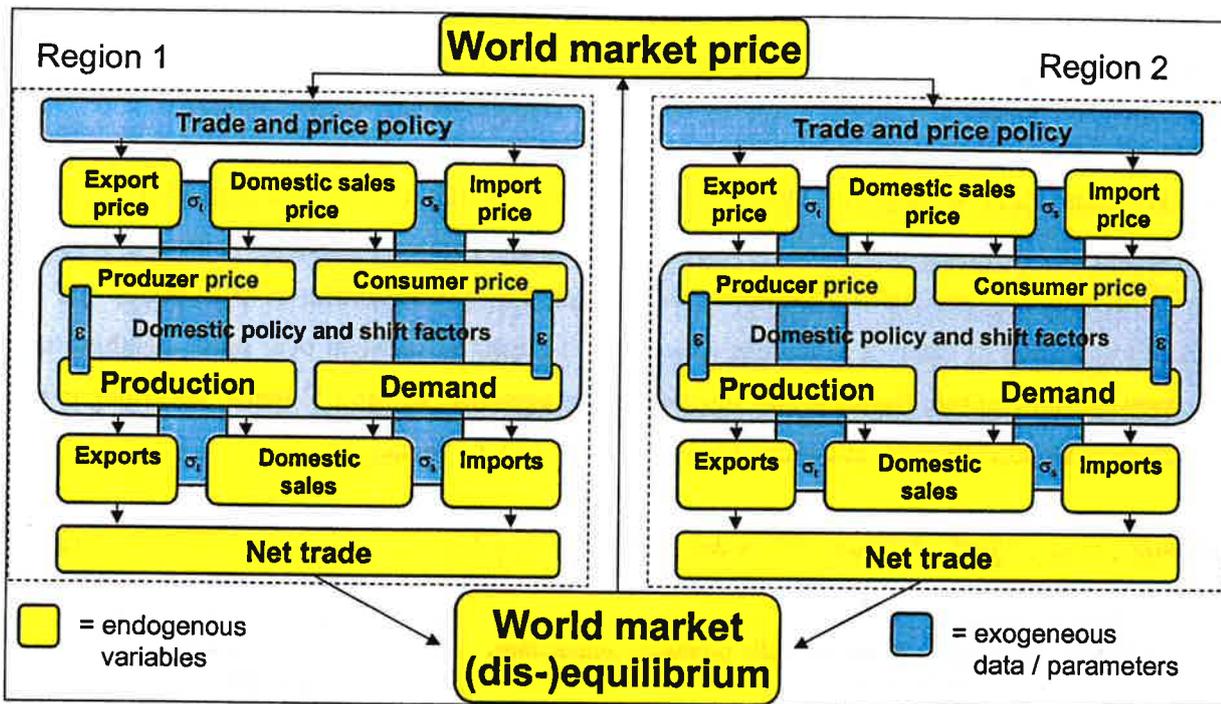
Figure 5.3. Regional differentiation of WATSIM



Source: WATSIM Modelling System

Figure 5.4 below shows the principal structure of the equilibrium model. In the core of the model, supply and demand (and their respective components) for each commodity market in each region are modelled as constant elasticity functions with respect to the relevant domestic own and cross prices ( $\epsilon$ ). While demand is differentiated to domestic sales and imports depending on the respective price ratio (assuming constant elasticities of substitution  $\sigma_s$ , CES), supply is divided into domestic sales and exports (assuming constant elasticities of transformation  $\sigma_e$ , CET). Net exports (positive or negative) from all regions meet on the single world market that has to be balanced. To achieve this after a shock (shifts, policy), world market prices are adjusted and transmitted to regional prices for imports and exports via the policy-driven price transmission. Together with the (equilibrium) domestic sales price, this results in adjustments in the producer and consumer prices according to the price aggregation derived from the CET and CES functions. Changed prices eventually induce the changes in supply and demand quantities necessary to balance world markets.

Figure 5.4. Schematic structure of WATSIM



Source: WATSIM Modelling System

While inter-regional relationships are represented by the world market clearing condition, intra-sectoral relationships are represented by means of the following issues:

- *Cross-price elasticities.* Both supply and demand are modelled considering the full set of cross-commodity price effects by using not only own-price elasticities, but also cross-price elasticities wherever applicable. In particular, this refers to substitution and complementary conditions within the human consumption bundle, within agricultural supply and within the feed mix.
- *Feed balances.* Feed energy use and the requirements from livestock production are balanced using feed energy balance equations. This ensures that, *ceteris paribus*, an increase in livestock production must be followed by an increase in feed demand.
- *Input-output ratios.* In the processing industries for oilseeds and for milk, constant input-output ratios ensure the balance between raw product processing and derived commodity production quantities.

### 5.3.2. Representation of regional gross trade<sup>65</sup>

Among a number of reasons that a given country or region both imports and exports a specific commodity within the same period is that the homogeneity assumption on commodities often is not

<sup>65</sup> This section heavily draws on von Lampe (2001).

met. <sup>66</sup> Domestically produced and imported goods of the same type are not considered equal by consumers, and producers supply different commodities to the domestic and foreign markets. Despite those differences, however, these commodity pairs to a certain degree represent substitutes for consumers or producers, implying a specific link between domestic and foreign markets.

The key assumption Armington (1969) made upon the relationship between the demand for a certain commodity and its distribution on domestically produced and imported quantities is that the elasticity of substitution between the two origins of one commodity is independent of both prices and the demand quantities of other commodities (though not necessarily constant over time), resulting in a *constant elasticity of substitution* (CES) function for the aggregate demand. <sup>67</sup> Hence, according to this assumption, the total demand of commodity *i* by region *r* may be written as:

$$DEMD'_{i,r} = sd_{i,r} * \left[ ddd_{i,r} * DSLS'_{i,r}^{-\rho d_{i,r}} + did_{i,r} * PIMP'_{i,r}^{-\rho d_{i,r}} \right]^{\frac{1}{\rho d_{i,r}}} \quad (2)$$

where:	DEMD	Total demand	<i>i</i>	Product index
	DSLS	Demand for domestically produced commodities, domestic sales	<i>r</i>	Region index
	PIMP	Demand for imported commodities, imports	<i>t</i>	Time index
	sd	Scaling parameter		
	ddd,did	Distribution parameters		
	pd	Substitution parameter ( $\rho d > -1$ )		

On the production side, Powell and Gruen (1968) have formulated similar relationships as on the demand side. Even if transformability between the production for domestic and export markets can be expected to be much stronger than on the demand side, information costs, different product qualities, labelling, etc give some arguments that transformation is limited, too. Hence the pendant of the CES function, the constant elasticity of transformation (CET) function, is employed in the following way:

$$SUPP'_{i,r} = ss_{i,r} * \left[ dds_{i,r} * DSLS'_{i,r}^{-\rho s_{i,r}} + des_{i,r} * PEXP'_{i,r}^{-\rho s_{i,r}} \right]^{\frac{1}{\rho s_{i,r}}} \quad (3)$$

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<sup>66</sup> There are several other possible arguments, including the geographical expansion of countries and regions (resulting in imports from one neighbour on one border while exporting from the other border to another partner), dynamics (resulting in imports in parts of a period, while exporting in other parts of the same period), specific bilateral trade agreements and others.

<sup>67</sup> In fact, Armington assumed that consumers would distinguish between products across various origins, i.e. between imports from different countries, and domestic commodities. We use a simplified approach by assuming imports from different countries to be fully substitutable. See the discussion on the theoretical limitations of this approach in the summary and conclusions.

where:	SUPP	Total supply	Other symbols already declared
	PEXP	Supply of export commodities, exports <sup>68</sup>	
	ss	Scaling parameter	
	dds,des	Distribution parameters	
	ps	Transformation parameter ( $\rho_s < -1$ )	

### 5.3.2.1. Derivation of model equations

#### The demand side

Employing the Lagrange function on the cost minimisation problem for the consumers, we can derive the functions that give us the shares of domestic sales and import in the total demand, depending on the price ratio of, respectively, domestic and imported goods:

$$DDSH'_{i,r} = \frac{DSLS'_{i,r}}{DEMP'_{i,r}} = \frac{1}{sd_{i,r}} * \left( ddd_{i,r} + did_{i,r} \frac{1}{1+\rho d_{i,r}} * ddd_{i,r} \frac{\rho d_{i,r}}{1+\rho d_{i,r}} * \left( \frac{CPIM'_{i,r}}{CPDS'_{i,r}} \right)^{\frac{\rho d_{i,r}}{1+\rho d_{i,r}}} \right)^{\frac{1}{\rho d_{i,r}}} \quad (4)$$

and

$$IMSH'_{i,r} = \frac{PIMP'_{i,r}}{DEMP'_{i,r}} = \frac{1}{sd_{i,r}} * \left( did_{i,r} + ddd_{i,r} \frac{1}{1+\rho d_{i,r}} * did_{i,r} \frac{\rho d_{i,r}}{1+\rho d_{i,r}} * \left( \frac{CPDS'_{i,r}}{CPIM'_{i,r}} \right)^{\frac{\rho d_{i,r}}{1+\rho d_{i,r}}} \right)^{\frac{1}{\rho d_{i,r}}} \quad (5)$$

where:	DDSH	Domestic demand share of total demand	Other symbols already declared
	IMSH	Import share of total demand	
	CPIM	Consumer price for imported commodities	
	CPDS	Consumer price for domestic sales	

Since the aggregate price must represent the average price of imports and domestic sales, weighted with the import and domestic share respectively, the aggregate price can be computed as a function of domestic and import prices as follows:

$$CPRI'_{i,r} = \frac{1}{sd_{i,r}} * \left[ ddd_{i,r}^{\sigma d_{i,r}} * CPDS'_{i,r}^{1-\sigma d_{i,r}} + did_{i,r}^{\sigma d_{i,r}} * CPIM'_{i,r}^{1-\sigma d_{i,r}} \right]^{\frac{1}{1-\sigma d_{i,r}}} \quad (6)$$

with

$$\sigma d_{i,r} = \frac{1}{1+\rho d_{i,r}} \Leftrightarrow \rho d_{i,r} = \frac{1-\sigma d_{i,r}}{\sigma d_{i,r}} \quad (7)$$

<sup>68</sup> Note that in the model, possible intervention purchases are added to the export position. On this point, see paragraph 5.3.3.

where: CPRI Aggregate consumer incentive price Other symbols already declared  
 $\sigma$  Elasticity of substitution ( $0 < \sigma < \infty$ )

Finally, just like in the net trade version of WATSIM, total demand and its components react to prices according to double-log functions with constant elasticities, e.g. for human consumption:

$$HCPC'_{i,r} = HCPC'_{i,r}{}^{shift} * \prod_j \left( \frac{CPRI'_{j,r}}{CPRI'_{j,r}{}^{bas}} \right)^{\epsilon_{ij,r}^{con}} \quad (8)$$

where: HCPC Human demand per capita Other symbols already declared  
 $\epsilon^{con}$  Price elasticity of human demand  
 shift Variable value in target period, given constant real prices

As a result, three relationships are needed for the demand side in the model:

- Aggregate commodity price is a function of prices for domestic and imported quantities, respectively.
- Total demand (or its components) is a function of aggregate commodity prices.
- **Import and domestic shares of total demand are functions of the price ratio between domestic and imported goods. The supply side**

Equations on the supply side can be easily derived in analogy to the demand side. Here, the elasticity of substitution is replaced by the elasticity of transformation, which has a negative sign. Production shares of domestic sales and exports are defined as<sup>69</sup>:

$$DSSH'_{i,r} = \frac{DLS'_{i,r}}{SUPP'_{i,r}} = \frac{1}{SS_{i,r}} * \left( dds_{i,r} + des_{i,r} \frac{1}{1+\rho_{i,r}} * dds_{i,r} \frac{\rho_{i,r}}{1+\rho_{i,r}} * \left( \frac{PPEX'_{i,r}}{PPDS'_{i,r}} \right)^{\frac{\rho_{i,r}}{1+\rho_{i,r}}} \right)^{\frac{1}{\rho_{i,r}}} \quad (9)$$

and

$$\frac{PEXP'_{i,r}}{SUPP'_{i,r}} = \frac{1}{SS_{i,r}} * \left( des_{i,r} + dds_{i,r} \frac{1}{1+\rho_{i,r}} * des_{i,r} \frac{\rho_{i,r}}{1+\rho_{i,r}} * \left( \frac{PPDS'_{i,r}}{PPEX'_{i,r}} \right)^{\frac{\rho_{i,r}}{1+\rho_{i,r}}} \right)^{\frac{1}{\rho_{i,r}}} \quad (10)$$

<sup>69</sup> Note that the export share captures not only actual exports, but also intervention purchases necessary to avoid subsidised exports to exceed the limits set by the URAA.

where: DSSH	Domestic supply share of total supply	Other symbols already declared
EXSH	Export share of total supply	
STOP	Political stock changes, intervention purchases	
PPEX	Producer price for exported commodities	
PPDS	Producer price for domestic sales	

The price aggregate can be represented by the following equation:

$$PPRI'_{i,r} = \frac{1}{SS_{i,r}} * \left[ dds_{i,r}^{\sigma_{S_{i,r}}} * PPDS_{i,r}^{1-\sigma_{S_{i,r}}} + des_{i,r}^{\sigma_{S_{i,r}}} * PPEX_{i,r}^{1-\sigma_{S_{i,r}}} \right]^{\frac{1}{1-\sigma_{S_{i,r}}}} \quad (11)$$

with

$$\sigma_{S_{i,r}} = \frac{1}{1 + \rho_{S_{i,r}}} \Leftrightarrow \rho_{S_{i,r}} = \frac{1 - \sigma_{S_{i,r}}}{\sigma_{S_{i,r}}} \quad (12)$$

where: PPRI	Aggregate producer incentive price	Other symbols already declared
$\sigma_S$	Elasticity of transformation ( $0 > \sigma > -\infty$ )	

Finally, again like in the net trade model, supply react to prices according to double-log functions with constant elasticities, e.g. for crop areas:

$$LEVL'_{i,r} = LEVL_{i,r}^{shift} * \prod_j \left( \frac{PPRI'_{i,r}}{PPRI_{i,r}^{bas}} \right)^{\epsilon_{i,r}^{sup}} \quad (13)$$

where: LEVL	Activity level, i.e. crop area (or animal number)	Other symbols already declared
$\epsilon^{sup}$	Price elasticity of supply	
shift	Variable value in target period, given constant real prices	

Again, a set of three relationships is needed to represent the supply side in the model:

- Aggregate commodity price is a function of prices for domestic and exported quantities, respectively.
- Total supply (or its components) is a function of aggregate commodity prices.
- Export and domestic shares of total supply are functions of the price ratio between domestic and exported goods.

### 5.3.2.2. Derivation, estimation or "guestimation" of parameters?

One of the most important questions in terms of the application of the Armington approach in a trade model is how to obtain appropriate parameters to fill the functional relationships described in the previous points. In particular, there are three sets of parameters necessary for the CES demand functions and the CET supply functions, including the elasticities of substitution and transformation, respectively, the distribution parameters and the scaling parameters. Given that the sum of distribution parameters must equal unity, there are thus three parameters to find for each region and commodity and each of the supply and demand sides. The discussion here focuses on the demand side, but the calculations on the supply side are done in an analogous way.

Since quantities and prices are known for the base year, the distribution and scaling parameters can be derived unambiguously if the elasticity of substitution is given, making use of equations (2) and (4). The distribution parameter  $ddd$  referring to domestic sales in total demand can be calculated from a given elasticity of substitution by using the following formula:

$$ddd_{i,r} = \frac{\left(\frac{CPDS_{i,r}^{bas}}{CPIM_{i,r}^{bas}}\right) * \left(\frac{DSLS_{i,r}^{bas}}{PIMP_{i,r}^{bas}}\right)^{\frac{1}{\sigma_{d,i,r}}}}{1 + \left(\frac{CPDS_{i,r}^{bas}}{CPIM_{i,r}^{bas}}\right) * \left(\frac{DSLS_{i,r}^{bas}}{PIMP_{i,r}^{bas}}\right)^{\frac{1}{\sigma_{d,i,r}}}} \quad (14)$$

The derivation of the remaining distribution parameter  $did$  and the scaling parameter  $sd$  is then straightforward.

Consequently, the problem of finding the necessary parameters reduces to the definition of the elasticities of substitution. Since these parameters describe the reaction of demand patterns due to price changes, they cannot be derived from base year data. Instead, there are two ways of handling this problem. One option would be to estimate the parameters based on available time series for demand and import quantities and domestic and import prices. The other option is the utilisation of parameters published in other sources, which is easier to do and fits to the general approach of a synthetic model. Due to data restrictions, but also because of resource limitations, the former option was impossible to realise for the WATSIM team. However, for the time being, reliable publications on elasticities of substitution between domestic and imported commodities (and even more so on elasticities of transformation between commodities for domestic and export markets) are lacking. The specification of market-specific elasticities is therefore postponed until further data becomes available. Instead,

WATSIM uses a value of +3.0 for the elasticity of substitution on all markets, and assumes a higher elasticity of transformation with -5.0.<sup>70</sup>

### 5.3.2.3. Regional exceptions

For a set of reasons, a number of markets were excluded from the Armington assumption. Markets are generally represented as net trade markets, if one of the following conditions was met in the base year: either imports or exports were (close to) zero or domestic sales were (close to) zero (i.e., either domestic demand was met exclusively by imports, or all domestic supply was exported).

Table 5.2. below shows those markets where the Armington assumption was dropped and net trade was modelled instead.

**Table 5.2. Markets in the WATSIM model represented by net trade rather than gross trade**

	E15	CEE	RUS	CHN	JAP	ANZ	USA	CAN	MER	ROW
BARL				Net trade						Net trade
MAIZ				Net trade	Net trade					
OCES					Net trade					Net trade
RICE		Net trade	Net trade					Net trade	Net trade	
STAR		Net trade	Net trade							
SUGA			Net trade	Net trade						
PULS					Net trade				Net trade	
SOYA	Net trade	Net trade			Net trade					
SUNF	Net trade	Net trade			Net trade					
RAPE					Net trade					Net trade
SEDO								Net trade	Net trade	
OSOY			Net trade							
OSUN									Net trade	Net trade
ORAP									Net trade	Net trade
CSOY						Net trade				
CSUN					Net trade	Net trade				
CRAP	Net trade		Net trade			Net trade			Net trade	
CSDO	Net trade									
BEEF					Net trade					
MEAO					Net trade			Net trade		
POUL									Net trade	
MILK			Net trade							
BTCR										Net trade
MILS					Net trade					

Source: WATSIM Modelling system

<sup>70</sup> A sensitivity analysis of the model outcomes to the values of the elasticities of substitution and transformation is provided in appendix 1.

### ***5.3.3. Representation of policy instruments***

The main objective of the modelling system WATSIM is the simulation of possible changes in agricultural policies, in particular in the context of the current WTO multilateral negotiations on further steps of trade liberalisation. Adopting the URAA classification, policy changes that could result from the Millennium Round may be categorised by three main issues: market access, domestic support and export subsidies. The representation of agricultural policy instruments in WATSIM closely relates to these topics.

#### ***5.3.3.1. Market access***

Four kinds of import barriers are represented in the WATSIM model, including specific tariffs, ad-valorem tariffs, flexible levies and – as implemented by a number of regions for complying with the UR minimum market access commitments – tariff-rate quotas. While specific and ad-valorem tariffs are represented by simple linear elements in the price transmission functions for imported goods<sup>71</sup>, both variable levies and tariff-rate quotas deserve a more elaborated discussion.

#### **Flexible levies**

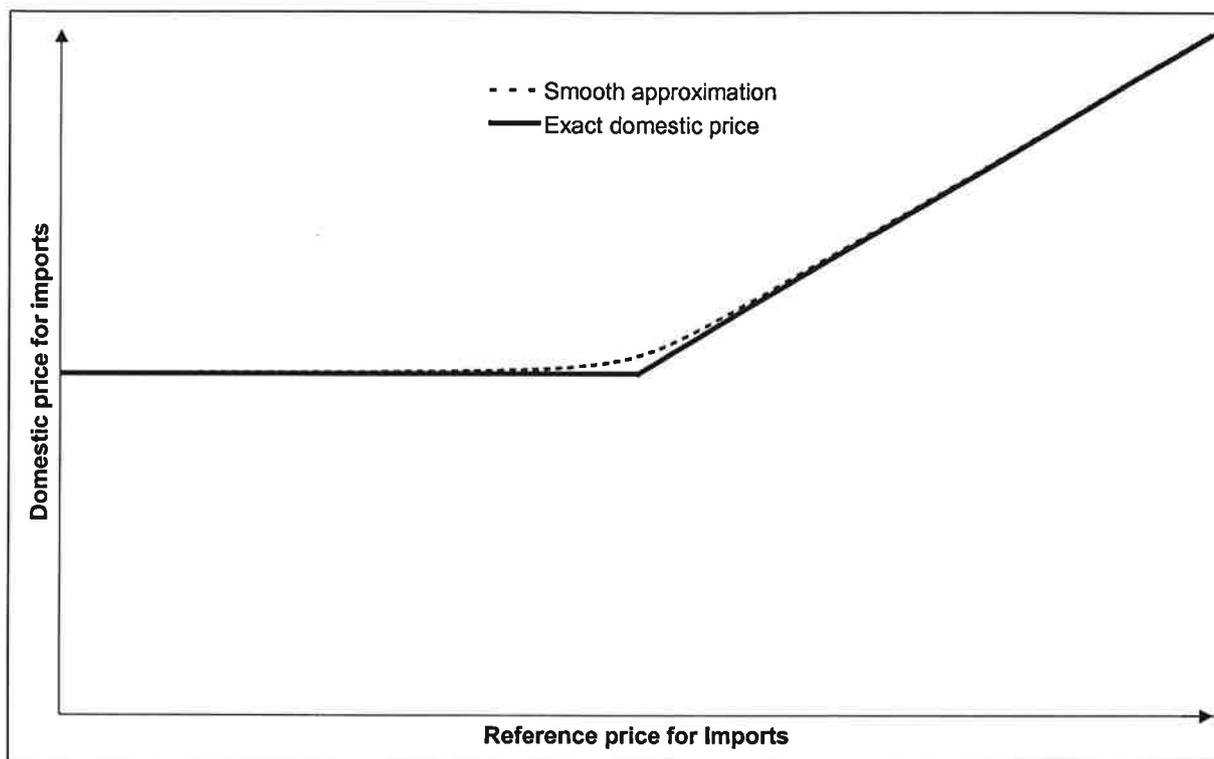
Flexible levies become relevant whenever a minimum import price is specified, which is independent from international prices. In real world, this may be due to administrative definition of threshold prices or to more or less continuous adjustments of applied tariffs according to changed foreign trade and internal prices. In WATSIM, flexible levies are modelled in those cases where agricultural policies involve defined price floors for domestic markets, such as the intervention prices in several Common Market Organisations of the EU, but also in other regions such as Japan.

Flexible levies, and hence minimum import prices, represent a policy measure that makes the price transmission function not only non-linear, but even non-differentiable. Figure 5.5 shows that, in that case, the transmission function has a knee where the reference price for imports is exactly at the minimum import price.

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<sup>71</sup> see von Lampe (1999), p. 26, for more details on this aspect.

**Figure 5.5. Graphical representation of the price transmission function in the case of a minimum import price**



Source: WATSIM modelling system

Given that this non-differentiable transmission function may cause a significant problem for solvers of non-linear programs<sup>72</sup> if initial values for the variables are not very close to the final solution, it is necessary to smoothly approximate the exact relationship. This is done by using the following formula<sup>73</sup>:

$$DPIM = 0.5 * \left( RPIM + MinDPIM + \sqrt{(RPIM - MinDPIM)^2 + (Delta * MinDPIM)^2} \right) \quad (15)$$

where: DPIM            Approximated domestic price for imports  
 RPIM                Reference price for imports  
 MinDPIM            Minimum domestic price for imports  
 Delta                Approximation parameter (see text)

The approximation parameter *Delta*, is gradually decreased in the solution process to reduce the approximation error. Note that the above equation exactly meets the *max*-formulation if *Delta* becomes zero.

<sup>72</sup> See paragraph 5.3.4 for the technical realisation of the model.

<sup>73</sup> Indices for regions, commodities and time are dropped for readability.

## Tariff-rate quotas

Tariff rate quotas (TRQs) were introduced after the URAA in the context of the minimum access commitments. TRQs may be globally defined or, referring to earlier trade partnerships, bilateral.

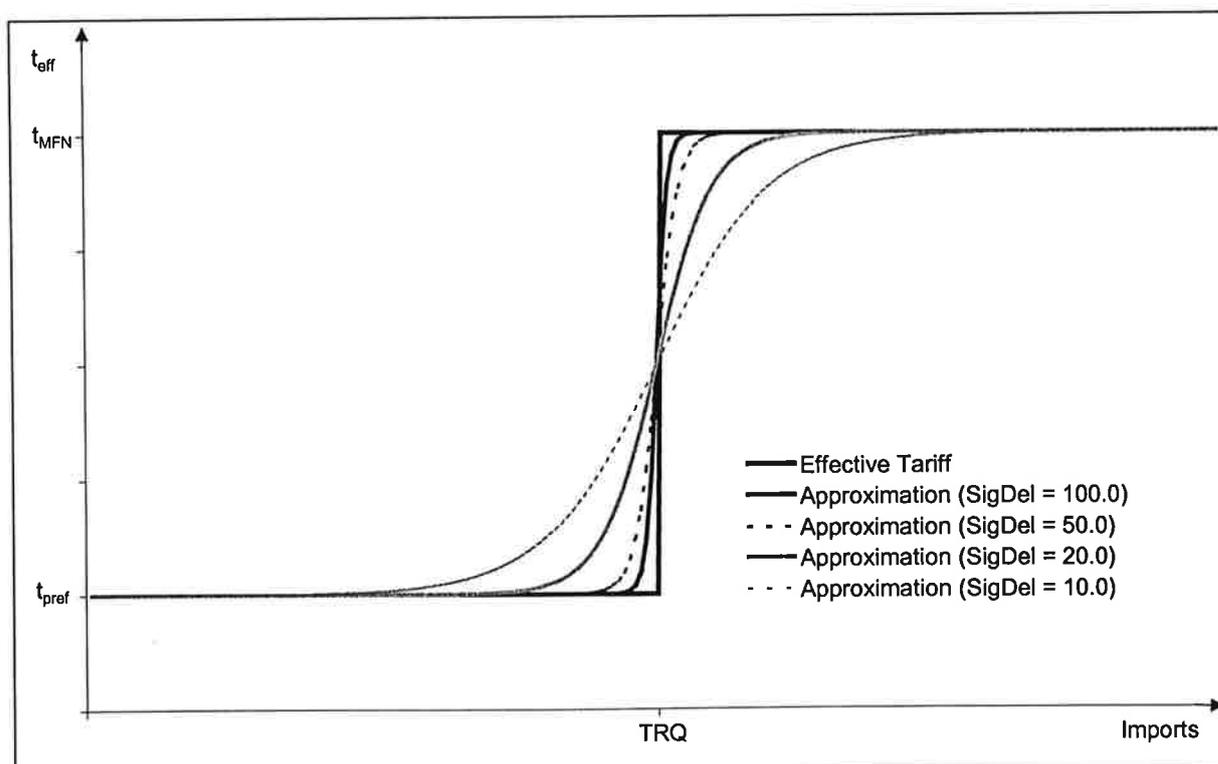
Generally, a TRQ consists of three distinct data, namely an import quota of a certain amount, a preferential tariff relevant for imports within the given quota, and the MFN tariff relevant for imports above the quota. Figure 5.6 illustrates the working of TRQs. As can be easily seen, the effective tariff can approach different levels, depending on the filling of the import quota:

- If the quota is unfilled, i.e., if imports are smaller than the import quota  $Q_{TRQ}$ , the effective tariff or “real protection”  $t_{eff}$  is equal to the preferential tariff  $t_{pref}$ .
- If the quota is overfilled, i.e., if imports exceed the import quota, the effective tariff is equal to the MFN tariff  $t_{MFN}$ .
- If the quota is exactly filled, i.e., if imports are equal to the import quota, the effective tariff may assume any value between  $t_{pref}$  and  $t_{MFN}$ , depending on the domestic market situation.

The latter situation is particularly interesting, since the real protection here is no longer exogenous to the system. Instead, the effective tariff has to be found such that the following condition holds:

$$DEMD + PEXP - PROD = TRQ \quad (16)$$

**Figure 5.6. Schematic representation of tariff-rate quotas and approximation by the model**



Note: The approximation of the effective tariff is discussed further below in the text.

Formally, the functional relationship between the level of imports and the effective tariff may be written as<sup>74</sup>:

$$\left\{ \begin{array}{ll} t_{eff} = t_{pref} & \forall PIMP < TRQ \\ t_{pref} \leq t_{eff} \leq t_{MFN} & \forall PIMP = TRQ \\ t_{eff} = t_{MFN} & \forall PIMP > TRQ \end{array} \right\} \quad (17)$$

where:  $t_{eff}$  Effective tariff rate, real protection (endogenous)  
 $t_{pref}$  Preferential tariff line (exogenous)  
 $t_{MFN}$  MFN tariff line (exogenous)  
 $PIMP$  Level of imports  
 $TRQ$  Import quota level, quantity

Obviously, this relationship is non-differentiable in the point where the level of imports is equal to the import quota. And this raises some problems for embedding tariff-rate quotas in the gross-trade framework of WATSIM. Indeed, this type of function is illegal for solve with available NLP solvers, such as the employed CONOPT2 solver.<sup>75</sup> It is therefore necessary to find a smooth way of representing the above relationship. Practically, we use a sigmoid approximation of the exact function (which is also represented in Figure 5.6):

$$t_{eff} = t_{pref} + \frac{\exp\left(\min\left(0, \left(\frac{PIMP - TRQ}{TRQ}\right) * SigDel\right)\right)}{1 + \exp\left(-abs\left(\left(\frac{PIMP - TRQ}{TRQ}\right) * SigDel\right)\right)} * (t_{MFN} - t_{pref}) \quad (18)$$

Two notes are in place to explain the sigmoid function. First, an additional parameter *SigDel* is introduced that allows to change the degree of approximation to the exact relationship. The larger this parameter, the closer the sigmoid function approaches to the exact, discrete function. Figure 5.6 presents the approximation with different values for the parameter *SigDel*, with higher values resulting in functions that closely approach the exact relationship. Second, in order to make the degree of approximation independent of the magnitude of the TRQ (and of the unit of measurement), the difference between the import quantity and the import quota is not entered in absolute terms, but relative to the quota quantity.

Given that the TRQ schedules allow for the specification of both specific and ad-valorem tariffs for both preferential and MFN levels, and that WATSIM traditionally works with both types of tariffs too, the above relationship is implemented for each of the tariff types in order to allow for maximum

<sup>74</sup> To improve readability, indices for the commodity and the region as well as the time index are omitted.

<sup>75</sup> In principle, this type of function corresponds to a mixed complementary problem (MCP) that could be solved by specific MCP solvers.

flexibility. Hence, from the point of implementation in the WATSIM framework, there is no need to transform specific tariffs into ad-valorem equivalents.

### *5.3.3.2. Domestic support*

Domestic support may occur by means of various policy measures, many of which are realistically portrayed by WATSIM. In principle, the model distinguishes between product-related payments (in particular, direct payments), factor-related payments (i.e., area payments and headage premiums), and production quotas. While the product-related payments are simply added in the price transmission function to increase the incentive prices, factor-related payments and production quotas again deserve some further elaboration.

#### **Factor-related payments**

Factor-related payments, such as the EU compensatory payments, are paid for each unit of production activity (i.e., land or livestock number) rather than per unit of production. Hence, they have a different impact on supply than price measures. In WATSIM however area and headage payments are transformed to price equivalents. Since WATSIM assumes yields to be independent from prices, area and headage payments can indeed be transformed to price equivalents by taking into account the (fixed) yields in the target year.

Even though this approach implicitly takes into account a degressive impact of area and headage payments in course of increasing yields, it still assumes full coupling of these payments to production. Although there has been a number of studies showing that area and headage payments are not fully coupled to production (see, e.g., chapter 4), trade models like WATSIM are not able to represent properly the partially coupled specificity of such policy instruments. Instead, the model allows for different assumptions on their degree of (de)coupling by weighing these payments with a coupling factor.<sup>76</sup>

#### **Production quotas**

Production quotas are an important quantitative tool to restrict (subsidised) supply in a number of markets, such as the EU sugar and milk markets, and the Canadian milk market. In WATSIM, production quotas are represented by fixing production quantities independently from current prices. This simplified representation ignores that the supply of other commodities depends on the production level of the quota product through the corresponding shadow price (i.e., marginal cost). Instead, it implicitly assumes that the supply of other commodities depends on the market price of the constrained product. Since the cost functions, in those markets where production is bound by a quota,

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<sup>76</sup> See sections 5.4 and 5.5 for simulations with different assumptions on the level of (de)coupling.

are not known and difficult to calibrate, WATSIM abstracts from this interesting but difficult problem.<sup>77</sup>

#### *5.3.3.3. Export subsidies*

Export subsidies play an important role particularly in the EU. They bridge the gap between high domestic market prices and lower foreign trade prices for exports. Just like import tariffs, they represent an element of the price transmission function on the export side, and can either be represented by a linear element or reflect a minimum export price policy. Both types are modelled in WATSIM in ways similar to the import side.<sup>78</sup>

The URAA involves commitments to reduce export subsidies and subsidised exports. WATSIM therefore considers upper limits of subsidised exports. They are endogenously taken into account in the model through the introduction of two adjustment options in the solution process:

- If administrated minimum prices are given, the model forces administrated stock purchases when subsidised exports exceed the corresponding upper UR limit.
- If no administrated prices are given, the magnitude of the per-unit export subsidy is reduced until exports meet the bound.

The question whether or not subsidies are necessary for exports (and hence, whether or not the export limit applies) depends on the domestic and reference prices for exports. However, exports without subsidies may be possible even if the average domestic price for exports is above the reference price, due to seasonal fluctuations and the volatility of prices across years. Due to its comparative static and annual structure, however, WATSIM cannot reflect this explicitly. According to von Lampe (1999, p. 74 f.), instead a 5% gap between the domestic and the reference prices is accepted to still allow for exports without subsidies.

#### *5.3.4. Technical realisation*

The WATSIM Data Base is realised in a fairly standardised way, making use of programming routines and data formats that are developed and used within the Institute for Agricultural Policy not only for this project, but for a number of other quantitative models as well, with some routines modified to fit the requirements of the WATSIM system. Most of these routines are based on the programming languages Fortran77 and C+ and use a user-friendly XVT-based interface. For the simulation model, all tasks related to data transfers (i.e., getting the data from the data base, and writing results back to

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<sup>77</sup> Chapters 7 and 8 deal with this question in the case of EU milk quotas.

<sup>78</sup> Note that, due to limited data availability on export subsidies, applied tariffs are often used as proxies for the magnitude of export subsidies.

the data base) are written in these languages as well, while the model algorithms are formulated in the *General Algebraic Modeling System* GAMS.<sup>79</sup> Eventually, to solve the various calibration models (elasticities, trade matrices) and to find the new equilibrium for a specific target year, the NLP solvers MINOS<sup>80</sup> and CONOPT2<sup>81</sup> are applied, the latter of which is particularly well suited for large models with many non-linear equations.

#### **5.4. Likely Medium-Term Developments on Agricultural World Markets: The WATSIM Reference Run**

Based on the year 1997, the WATSIM reference run aims to reflect likely developments on regional and international markets for agricultural commodities for the target years 2005 and 2010. While it is subject to numerous uncertainties, that have to be taken into account for the interpretation of the outcome, it is the result of careful consideration of the influencing factors on the supply and demand side. This section will first briefly discuss the main underlying assumptions on both the macro-economic and sectoral framework and the agricultural policies. Following that, the main results of the reference run will be presented and discussed in the context of the historical background, and of other market projections.

##### **5.4.1. Basic assumptions**

On the macro-economic side, general assumptions were basically taken from other publications. Population growth and urbanisation is assumed to follow the estimations published by the United Nations (1998). Income estimations follow those of the World Bank (1998) and the International Monetary Fund (1998). In addition, projections used by the Food and Agriculture Policy Research Institute (FAPRI, 2000) are taken into account. Exchange rates are assumed to be at their 1997 levels (for the Euro-US\$ rate, it is held constant at 1.05 US\$/€). Trends for agricultural land use are estimated considering the increasing urbanisation and, similar to irrigation trends, counterchecked with Alexandratos (1997).

With respect to agricultural policies, the reference run represents a status-quo simulation. Agricultural policies are assumed to remain as they were in the base year, unless other decisions are already made. In particular, this means the full incorporation of the Uruguay Round Agreement on Agriculture (URAA), including reductions in tariffs, domestic support and subsidised exports. For the United States, the reference run assumes full implementation of the 1996 Fair Act, implying the removal of all coupled payments, even though a number of additional measures were used in recent years. For the

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<sup>79</sup> Brooke et al. (1997).

<sup>80</sup> Gill et al. (2001).

<sup>81</sup> ARKI Consulting and Development (2001).

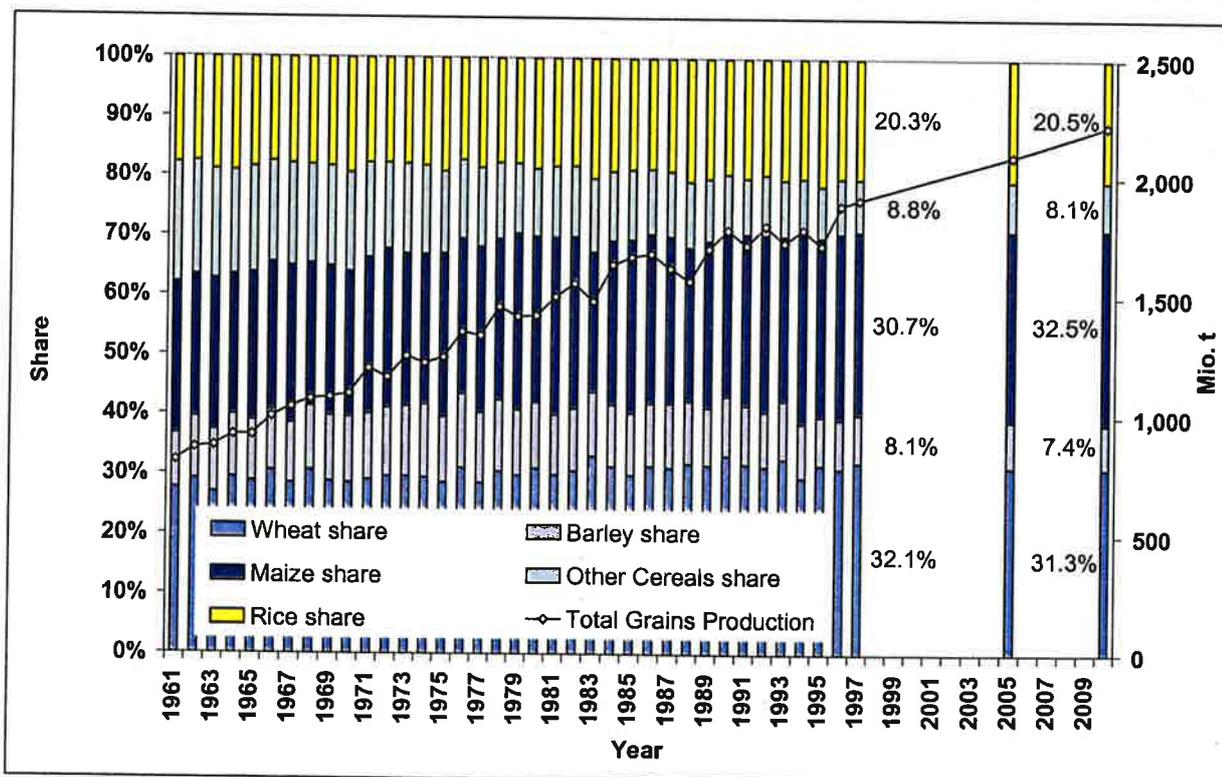
European Union, policy is assumed to follow the Agenda 2000 resolution, implying the reduction of intervention prices, the increase of compensatory payments for cereals and beef, the reduction of oilseed payments to the level applied for cereal areas. Set-aside is assumed to be at the default rate of 10%, with small producers being exempted from the set-aside obligation.

#### 5.4.2. Likely developments on agricultural markets<sup>82</sup>

##### 5.4.2.1. Grains

World grain production is projected to continue its growth at a slightly reduced rate of 1.2% per year, reaching a total of 2.2 billion tonnes in 2010 (see Figure 5.7). The strongest growth is found for maize, extending its share in total grain supply from below 31% to almost 32.5%. While rice is also projected to grow above average, barley and other cereals markets are expected to grow at moderate rates only, decreasing their combined share in world grain production from 17% in the base year to below 16% in 2010. The increase of the maize share is particularly due to the rising importance of feed cereals in some important regions, such as China (see below).

Figure 5.7. Global grain production (incl. rice) and shares of individual types of grains, 1961-1997 and projections to 2010



Source: WATSIM Data Base, WATSIM reference run

<sup>82</sup> All results can be found in detailed tables in the Complementary Data File provided in accompanying diskettes. Aggregated results are also included in appendix 2.

Clearly, the structure of grain production differs significantly across regions. While rice dominates in Japan, China and other parts of Asia, maize is the main type of cereals in the US and the Mercosur region (Table 5.3). Wheat still represents the most important type of grains in most developed regions. This general structure in grain production will remain relevant in the medium term as well, as indicated by the reference run.<sup>83</sup>

**Table 5.3. Global grain production and its regional breakdown by cereal types, 1997**

	<b>E15</b>	<b>CEE</b>	<b>RUS</b>	<b>CHN</b>	<b>JAP</b>	<b>ANZ</b>	<b>USA</b>	<b>CAN</b>	<b>MER</b>	<b>ROW</b>
<b>Total grain production (mio. t)</b>	<b>206.9</b>	<b>83.3</b>	<b>86.7</b>	<b>378.3</b>	<b>9.2</b>	<b>31.6</b>	<b>334.6</b>	<b>49.6</b>	<b>86.8</b>	<b>640.9</b>
<b>Wheat</b>	46%	38%	51%	33%	6%	62%	20%	49%	23%	29%
<b>Barley</b>	25%	16%	24%	1%	2%	22%	2%	27%	2%	5%
<b>Maize</b>	19%	27%	3%	28%	<1%	2%	70%	14%	61%	19%
<b>Other cereals</b>	9%	19%	22%	3%	<1%	11%	6%	9%	5%	11%
<b>Rice</b>	1%	<1%	<1%	36%	91%	3%	2%	<1%	9%	35%

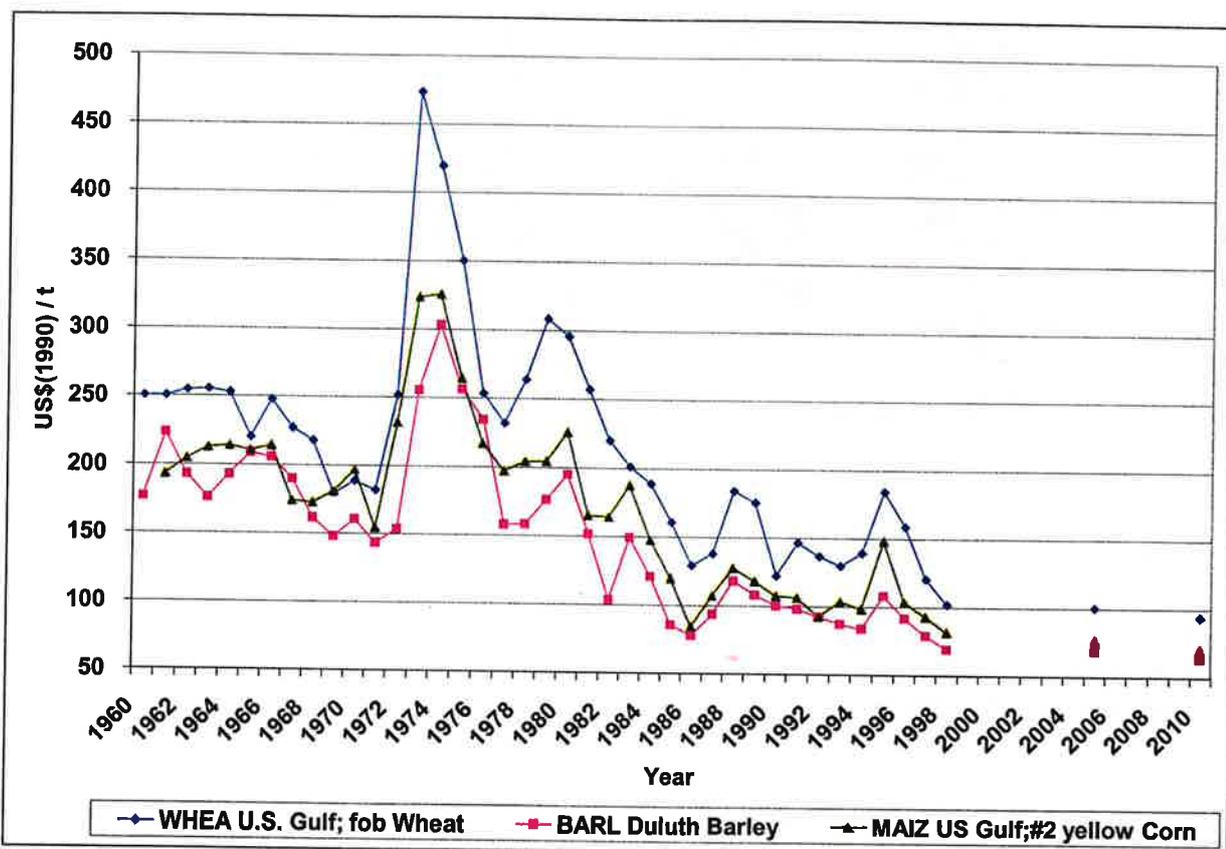
Source: WATSIM Data Base

International reference prices for cereals – as well as for other agricultural commodities – showed a significant depression after the peaks in the mid-1990s (see Figure 5.8). Prices are projected to recover over the projection period, with average rates of real price changes ranging between -1.6% and -2.1% per year over the projection period for the main cereals, and a stronger -0.3% per year for rice (see Figure 5.9). Given the current depression, price projections in general are more favourable for the second sub-period than for the 1997-2005 period.

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<sup>83</sup> See the discussion on regional developments below.

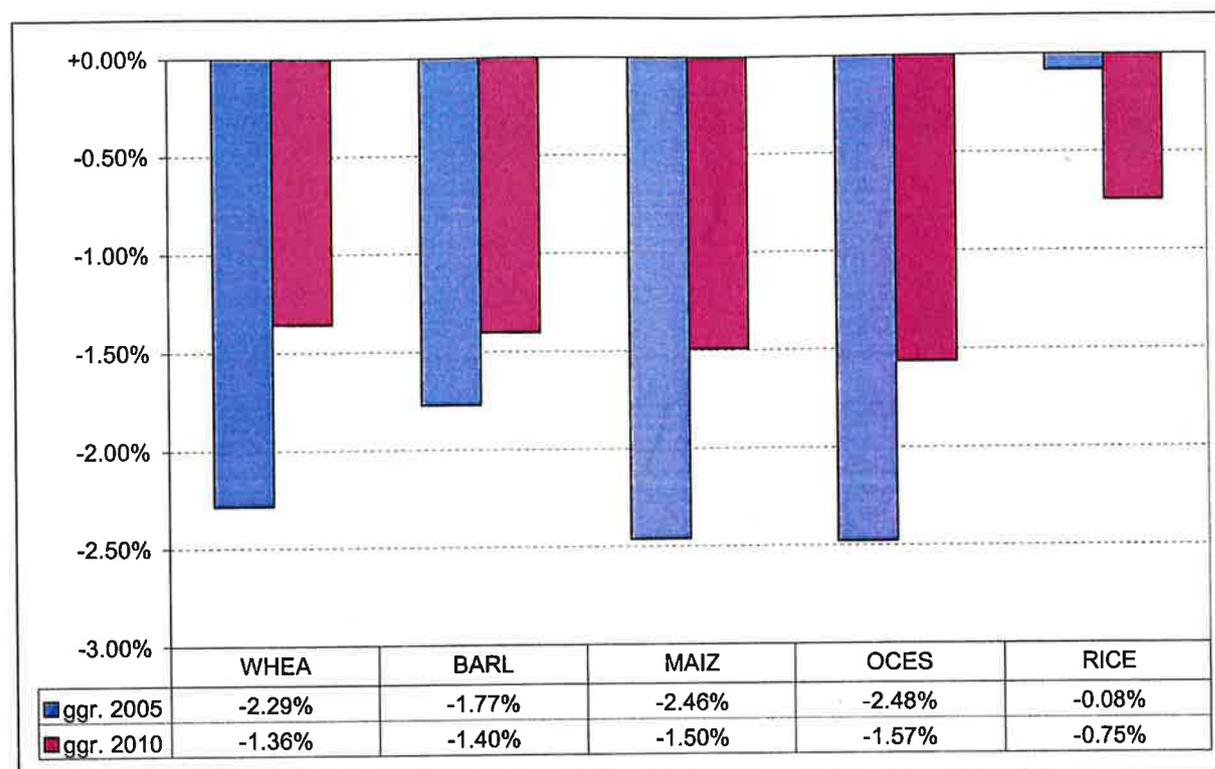
**Figure 5.8. International reference prices for grains, 1960-1998 and projections to 2010**



Source: USDA, WATSIM reference run

Note: Projections are calculated from 1997 prices and simulated changes of real world market prices.

**Figure 5.9. Real world market price projections for grains, 1997-2010**



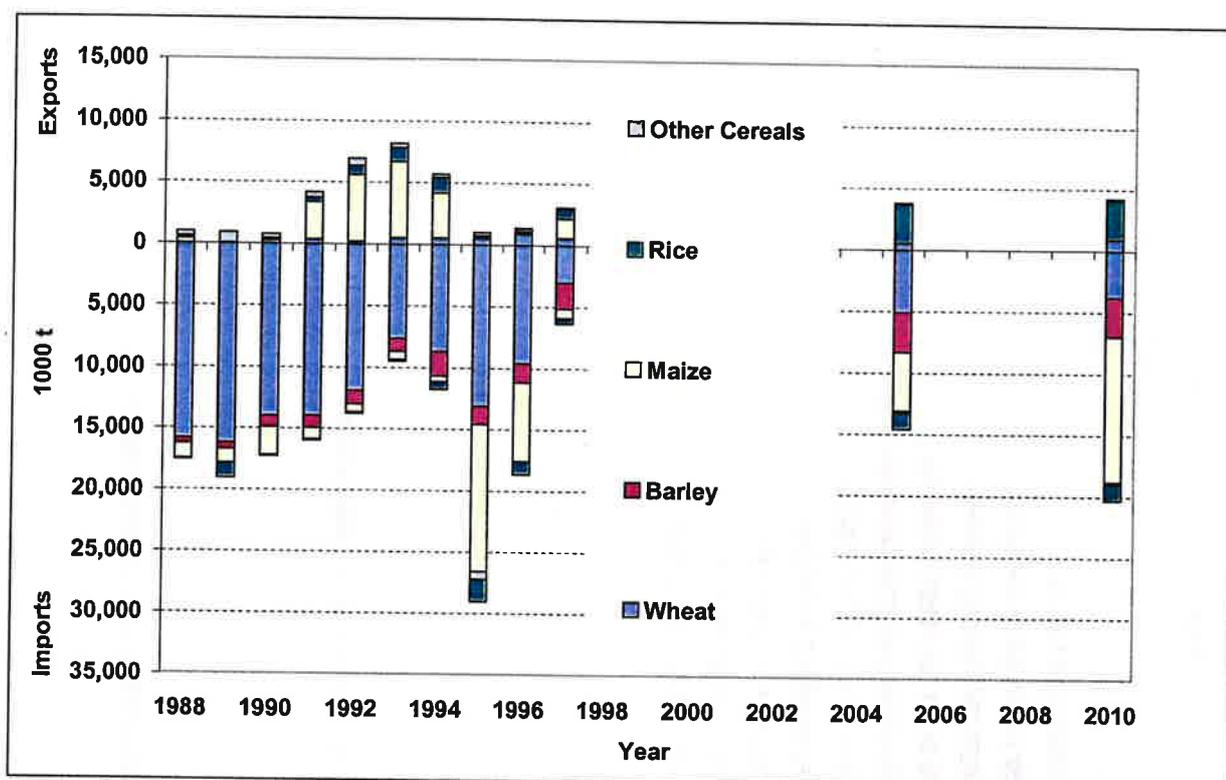
Source: WATSIM reference run

Since the mid-1980s, China has been the largest grain producer in the world. Together with the US and the EU, it produces almost 50% of world grain, with their share in total grain demand being somewhat smaller at 43%, and most of the remainder in both supply and demand (33% and 40%, respectively) being located in the Rest of the World aggregate.

In China, 30% of the domestic grains demand is used for livestock feed, a relatively small share as compared to industrialised countries where the feed cereal shares range around 50%. According to the reference run, however, the share of Chinese feed use will reach 39% by 2010, a result from the significant expansion of livestock production, particularly poultry and pig meat (see below). Given that 80% of Chinese feed grains comes from maize, domestic corn demand is projected to increase significantly with an average 2.6% per year, compared to 0.2% and 0.4% per year growth in wheat and rice demand, respectively. Production of maize is projected to slightly lag behind the demand development, inducing an import of some 12 mio. tonnes by 2010 (see Figure 5.10). At the same time, there will be some imports of wheat and barley, adding to some 20 mio. tonnes of cereal imports, while another 3 mio. tonnes of rice will be exported. According to these projections, China will act as a moderate importer of coarse grains only, rather than putting real pressure on international markets as

projected by some extreme positions.<sup>84</sup> This will contribute to the relatively weak development of international grain prices.

**Figure 5.10. Development of gross exports and imports of grains by China, 1988-1997 and projections to 2010**



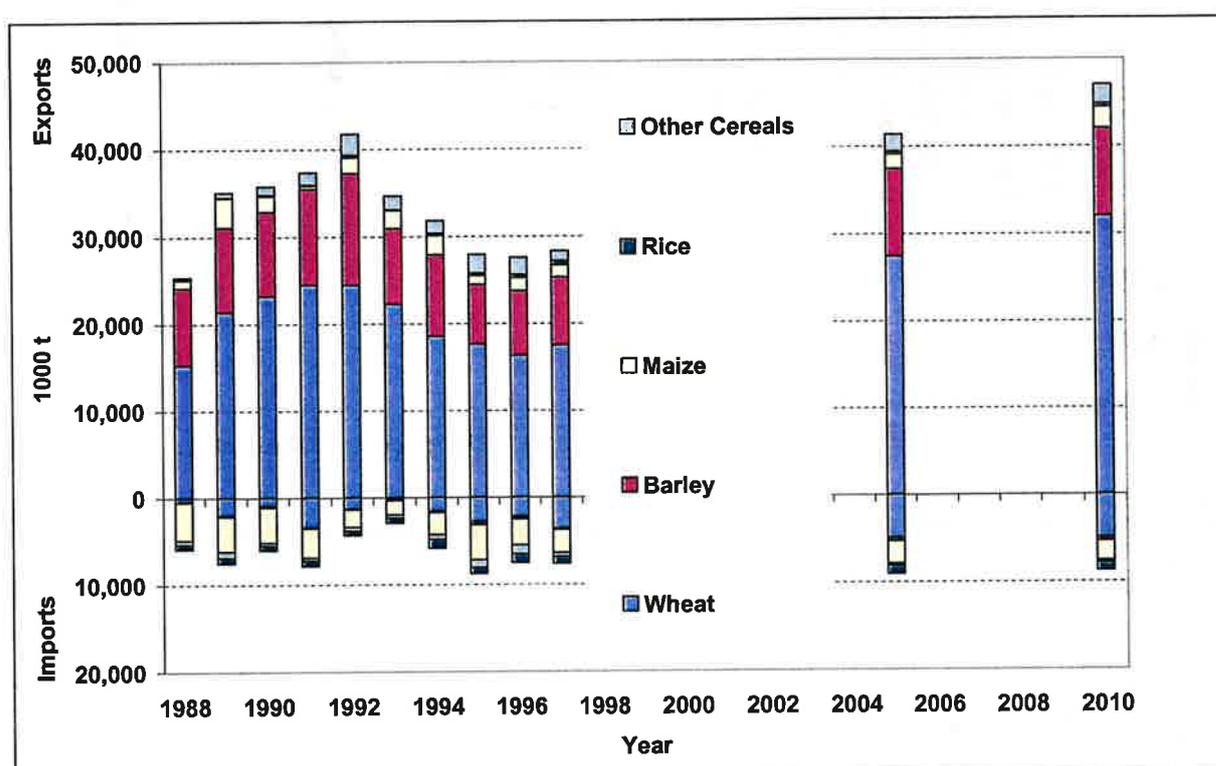
Source: WATSIM Data Base, WATSIM reference run. Projections refer to net trade for markets indicated in Table 5.2.

For the European Union, the main factor driving grain markets is the Agenda 2000 reform that is assumed to be completely enforced by 2005. Due to the reduction of administrated prices and a competitive exchange rate of 1.05 US\$ per €, wheat exports are projected to be possible without the use of export subsidies already by 2005. Therefore, over the projection period, the domestic price of wheat will depend more on international markets than on the administrated cereal prices, resulting in a strengthening of the relative price of wheat among the EU cereals. Wheat production would therefore be the main winner of the policy reform, with 106 mio. tonnes in 2005 and 111 mio. tonnes in 2010. The growth in supply is projected to be moderate for maize and rice and negative for barley and other cereals. On the demand side, the development is less favourable for wheat due to its comparatively

<sup>84</sup> See e.g. McCalla (1994) and the sources cited there.

high price.<sup>85</sup> Additional feed demand is projected also for maize. Consequently, EU wheat exports are projected to increase significantly, reaching some 27 and 32 mio. tonnes in 2005 and 2010, respectively (see Figure 5.11). At the same time, wheat imports are projected to expand somewhat to reach 5 mio. tonnes in each of the target years, up from 3.6 mio. tonnes in the base year. Bound by the limit on subsidised exports, barley exports are projected with 10 mio. tonnes in both target years, assuming this allocation of export subsidies in the coarse grains aggregate. Without adjustments in the price or set-aside policy<sup>86</sup>, some 1.1 mio. tonnes of barley would have to be purchased by intervention stocks in 2005, and some 0.6 mio. tonnes in 2010.

**Figure 5.11. Development of gross exports and imports of grains by the EU, 1988-1997 and projections to 2010**



Source: WATSIM Data Base, WATSIM reference run

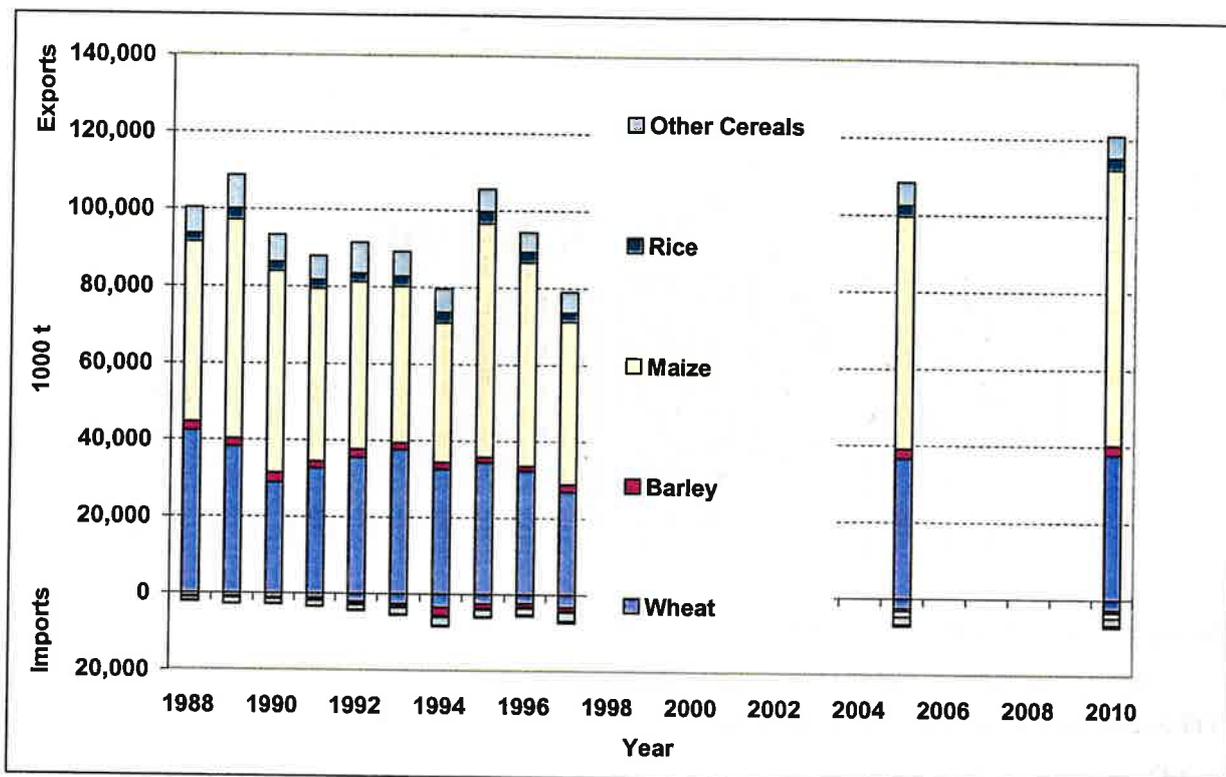
The US is projected to strengthen its position as the largest grain exporter in the world. Despite a moderate growth rate of 1.2% p.a. in cereals production over the projection period, total US grain exports are projected to exceed 120 mio. tonnes by 2010, up from some 79 mio. tonnes in the base year (Figure 5.12). By far the largest share both in production and exports is contributed by maize,

<sup>85</sup> Note that the model abstracts from the fact that an increasing part of EU wheat production might be feed wheat, that is not exportable at competitive prices, and may therefore be particularly interesting for livestock producers due to its higher energy and protein content as compared to coarse grains. In fact, this might result in somewhat lower wheat exports and hence higher world market prices.

<sup>86</sup> The set-aside rate in the EU is assumed at 10% throughout the projection period.

output of which increases at an average 1.5% p.a. Wheat exports, in contrast, though increasing as well, are projected not to exceed the levels already reached in the early 1990s.

**Figure 5.12. Development of gross exports and imports of grains by the US, 1988-1997 and projections to 2010**

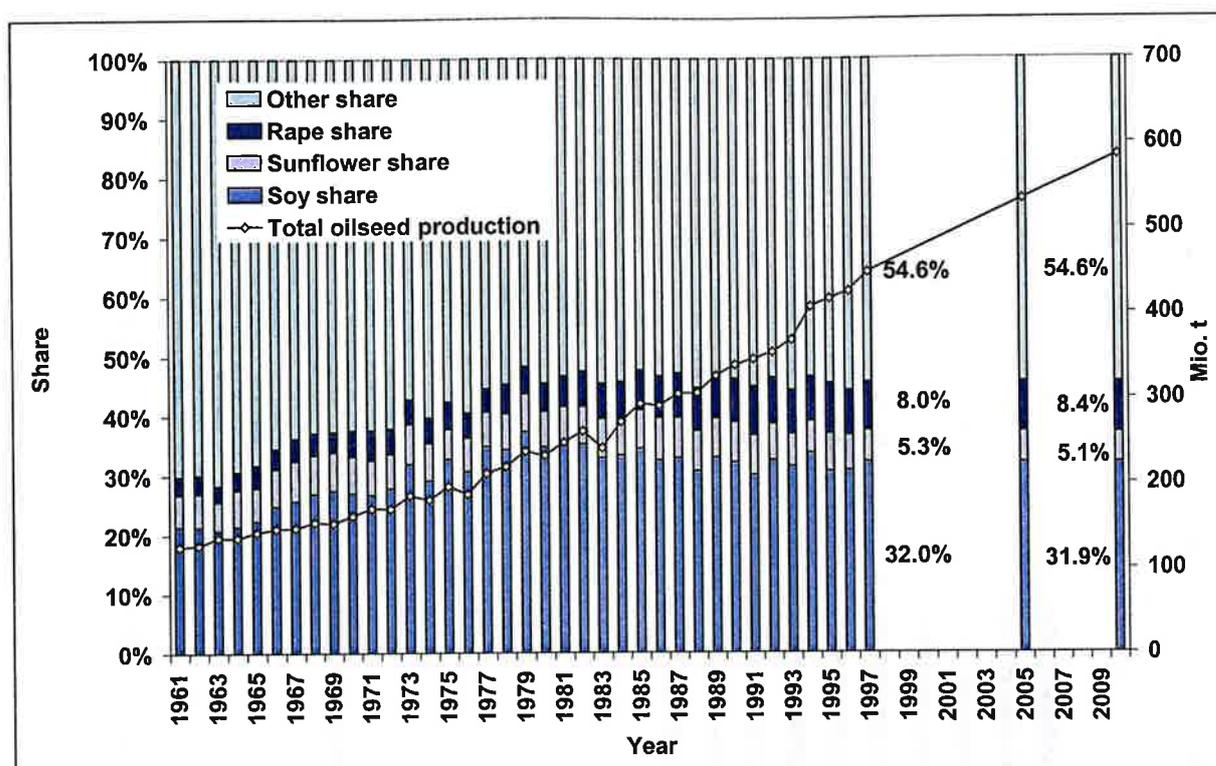


Source: WATSIM Data Base, WATSIM reference run

#### 5.4.2.2. Oilseeds

World oilseed production is projected to grow with an average 2% p.a., reaching almost 585 mio. tonnes by 2010 (Figure 5.13). All four categories of oilseeds are to contribute to this growth, with a slight shift from sunflower towards rape seeds. Other oilseeds, however, and here particularly oil palm products, represent the largest part of total oilseed production. This is particularly true for the Rest of the World aggregate, but holds for China as well. In Canada and the EU, rape seed is the dominant oilseed, while in the US and Mercosur, soybean represents basically all oilseed production. Sunflower seed is particularly important in Russia (Table 5.4). Production of vegetable oils and oil cakes is projected to show similar growth, with oils reaching some 108 mio. tonnes in 2010, and oil cakes reaching almost 200 mio. tonnes. While again the largest share of vegetable oils comes from other oilseeds, the main source for oil cakes, which represent an important protein feed, is soybean, resulting from its high protein content.

Figure 5.13. Global oilseed production and shares of individual types of oilseeds, 1961-1997 and projections to 2010



Source: WATSIM Data Base, WATSIM reference run.

Table 5.4. Global production of oilseeds, vegetable oils and oil cakes, and regional break-down by oilseed types, 1997

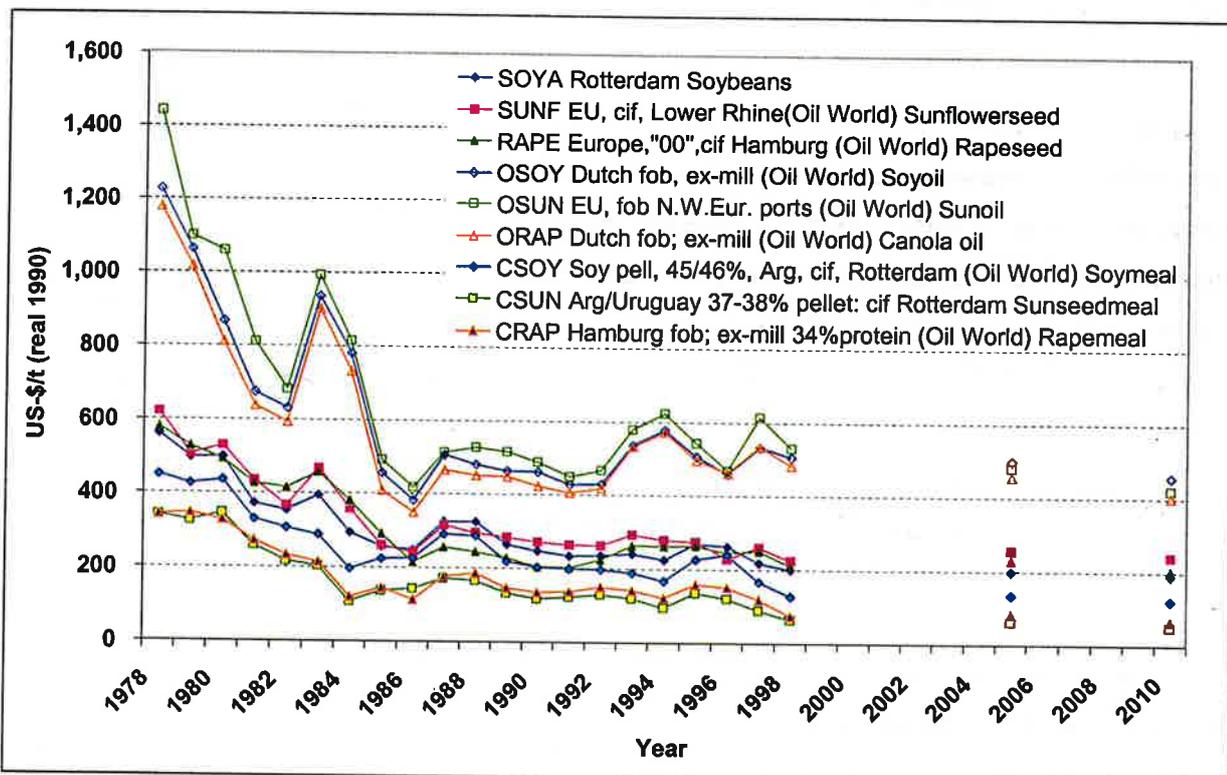
	USA	MER	CHN	E15	CAN	CEE	RUS	ANZ	JAP	ROW
<b>Oilseeds</b>	<b>83130</b>	<b>50380</b>	<b>45698</b>	<b>26903</b>	<b>10334</b>	<b>3794</b>	<b>3305</b>	<b>2000</b>	<b>196</b>	<b>221599</b>
Soybean	88%	82%	32%	5%	26%	5%	8%	4%	74%	4%
Sunflower seed	2%	11%	3%	15%	1%	51%	86%	7%	0%	3%
Rape seed	1%	0%	21%	32%	64%	42%	5%	43%	1%	4%
Other oil seeds	9%	7%	44%	47%	9%	2%	1%	46%	26%	89%
<b>Vegetable oils</b>	<b>9705</b>	<b>8695</b>	<b>8820</b>	<b>11666</b>	<b>1737</b>	<b>1509</b>	<b>787</b>	<b>245</b>	<b>1857</b>	<b>39143</b>
Soybean oil	74%	65%	20%	23%	16%	3%	2%	6%	37%	6%
Sunflower oil	4%	26%	5%	21%	1%	54%	94%	26%	0%	5%
Rape oil	2%	0%	33%	27%	79%	39%	2%	22%	46%	7%
Other veg. oil	20%	8%	43%	29%	5%	5%	1%	46%	16%	82%
<b>Oil cakes</b>	<b>34859</b>	<b>27779</b>	<b>21890</b>	<b>20265</b>	<b>3207</b>	<b>2038</b>	<b>940</b>	<b>502</b>	<b>4533</b>	<b>37896</b>
Soybean cake	89%	88%	40%	57%	38%	9%	8%	13%	64%	28%
Sunflower cake	1%	9%	3%	15%	0%	48%	87%	8%	0%	7%
Rape cake	1%	0%	24%	21%	58%	40%	3%	8%	26%	13%
Other oil cakes	9%	4%	33%	7%	3%	3%	2%	70%	11%	53%

Source: WATSIM Data Base; all quantities in 1000 t.

While for soybean, sunflower and rape, both the seeds, oils and cakes are traded, other oilseeds are traded almost exclusively in their processed forms, i.e. as oils and cakes. International prices for oilseeds are projected to develop relatively strongly as compared to cereal prices. Real seed prices are to decline in real terms by less than or around  $-1\%$  per year, with the exception of rape seed (Figure 5.15). This is roughly what was observed during the late 1980s and 1990s (see Figure 5.14), while it implies some recovery from the depression of recent years.<sup>87</sup>

Real prices for vegetable oils are also projected to decline by moderate rates only. Particularly soybean oil shows annual growth rates comparable to those for seeds, whereas real prices for other oils are expected to decline at somewhat higher rates of  $-2.8\%$  p.a. over the projection period, due to the strong growth of the oil-rich palm crops. The strongest decline is projected for real oil cake prices, again particularly for other oil cakes, with up to  $-7\%$  p.a. over the second sub-period, while again soycakes are expected to develop somewhat stronger.

**Figure 5.14. International reference prices for oilseeds and products, 1978-1998 and projections to 2010**

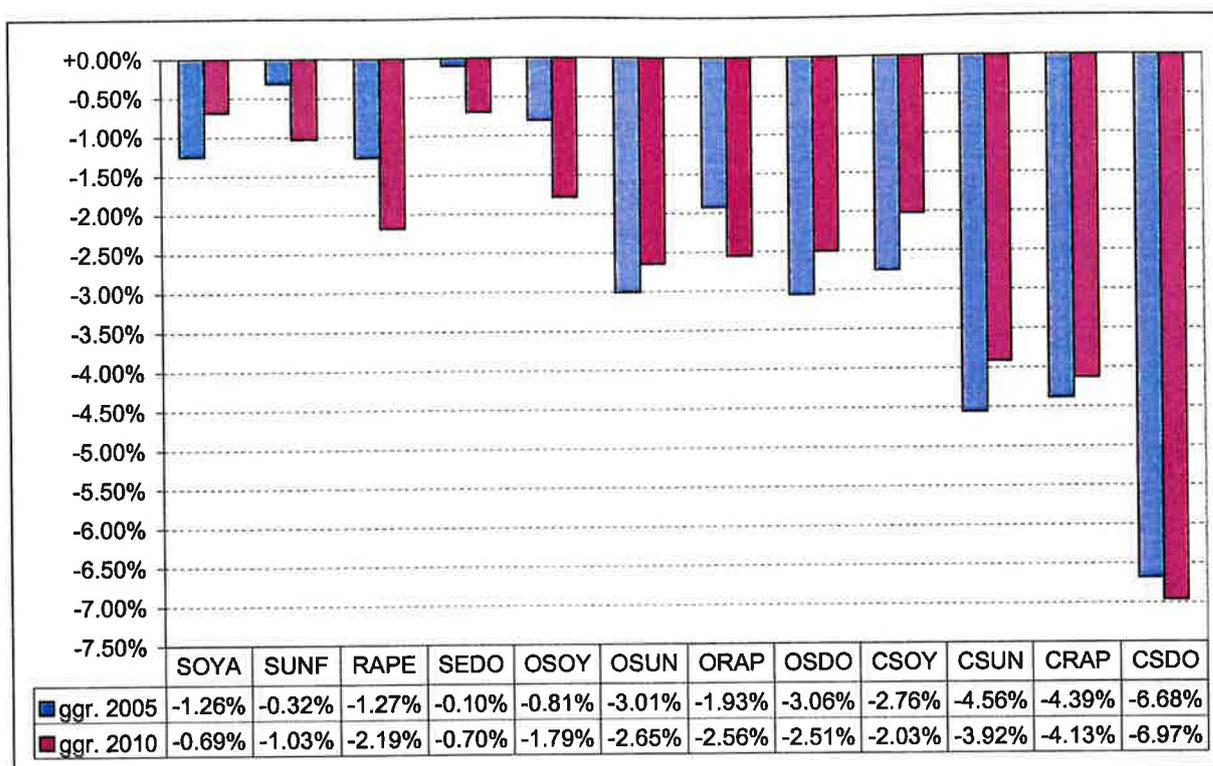


Source: USDA, WATSIM reference run

Note: Projections are calculated from 1997 prices and simulated changes of real world market prices.

<sup>87</sup> Note that recent payments for US farmers in excess to Fair-Act payments, that may have contributed to the relatively low prices in the past, are not assumed for the target years in this reference run. Such payments, however, could induce higher US supply on international markets and would therefore reduce world market prices.

**Figure 5.15. Real world market price projections for oilseeds and products, 1997-2010**



Source: WATSIM reference run.

Despite the fact that livestock production in the EU is projected to increase with moderate rates only (see below), the region is expected to have a continuous import demand for oil cakes and, with the exception of rape, oilseeds. Given the moderate growth of oil demand in human consumption, the increasing oilseed crush leads to increasing oil exports by the EU. Rape seed is the main oilseed in this region, with basically all seeds being crushed in the Union, and oil exports projected to further increase (Figure 5.18). On the other hand, 26% of sunflower crush, and more than 80% of soybean crush, are imported from abroad, making the region the largest oilseed importer (Figures 5.16 and 5.17). Similar to the rape markets, cakes are needed for livestock production in excess of the domestic supply, while oil exports are projected to slightly increase over the projection period.

The US are by far the largest soybean exporter, and export significant quantities of soybean oil and cake, too (Figure 5.16). At reverse, the US show only small foreign trade on the sunflower and rape markets. Soybean production is projected to continue its comparatively strong growth, particularly in the first sub-period. While livestock production, and particularly poultry supply, is also expected to expand significantly, projections still show some increase in soybean cake exports. Soy oil exports are projected to increase with even higher rates due to a moderate growth in domestic human consumption.

Similar to the US, the Mercosur region exports significant amounts of soybean, and is the largest exporter of soy oil and soy cake. On the markets for sunflower oil and cake, this region is the largest

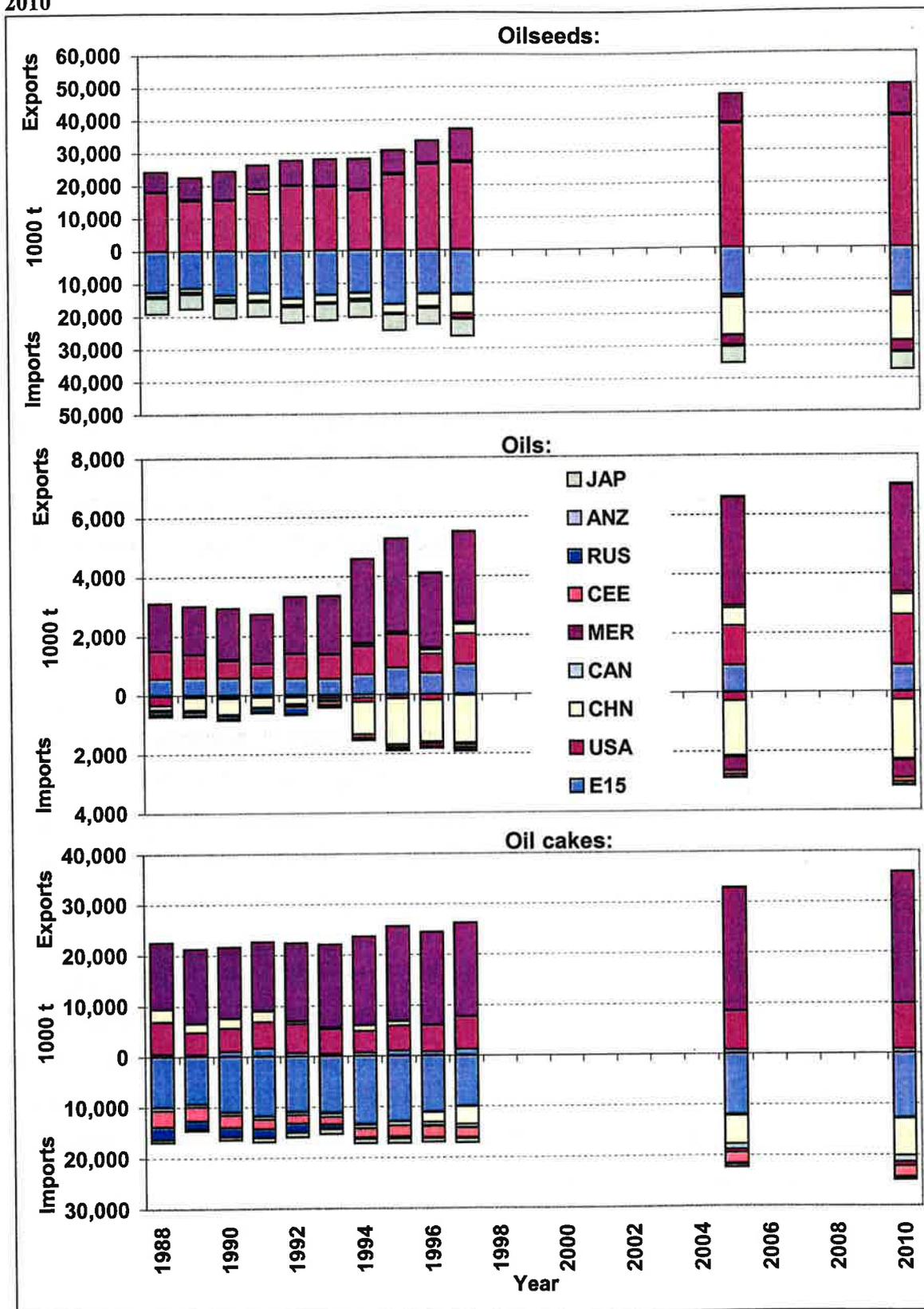
exporter, too (Figure 5.17), while it does not show significant trade on the rape market. Soybean production is projected to increase significantly, though at somewhat more moderate rates than in the US. Basically all additional soybean seeds are expected to be crushed domestically, leaving soybean exports more or less unchanged over the projection period. Given that more than 50% of the soy oil production and 75% of cake supply are exported, the significant growth of domestic oil and cake demand does not prevent this region from a significant further increase in its exports of these products. The Mercosur region is the world's largest sunflower seed producer. And supply of sunflower seeds in Mercosur is also projected to increase significantly. Virtually all quantities are used for oil and cake exports, which are projected to increase correspondingly.

While being a minor player on the soya and sunflower markets, Canada represents one of the main rape (canola) producers and exports significant quantities of both rape seed, oil and cake (Figure 5.18). The projected increase of rape production (2.8% p.a. in average, with 1997 corresponding to a below average rape harvest in Canada) results in a strong expansion of rapeseed exports, whereas oil exports are projected to increase more moderately. Due to its strong growth in meat production, Canadian rape cake exports are projected to decrease slightly between 1997 and 2010.

China is the world's largest rapeseed producer, and produces significant quantities of soybean and sunflower seed as well. In contrast to western regions, about one fourth of China's domestic demand for soybean comes from human consumption. Production of rapeseed is projected to continue its strong growth with almost 3% p.a. Due to the overall economic growth, however, domestic demand for rape seed, and particularly for oil and cakes, is projected to increase even stronger, resulting in some seed imports and significant imports of rape oil and cake (Figure 5.18). Similarly, China is projected to expand imports on the soy markets, both in terms of soybean, and in terms of oil and cake.

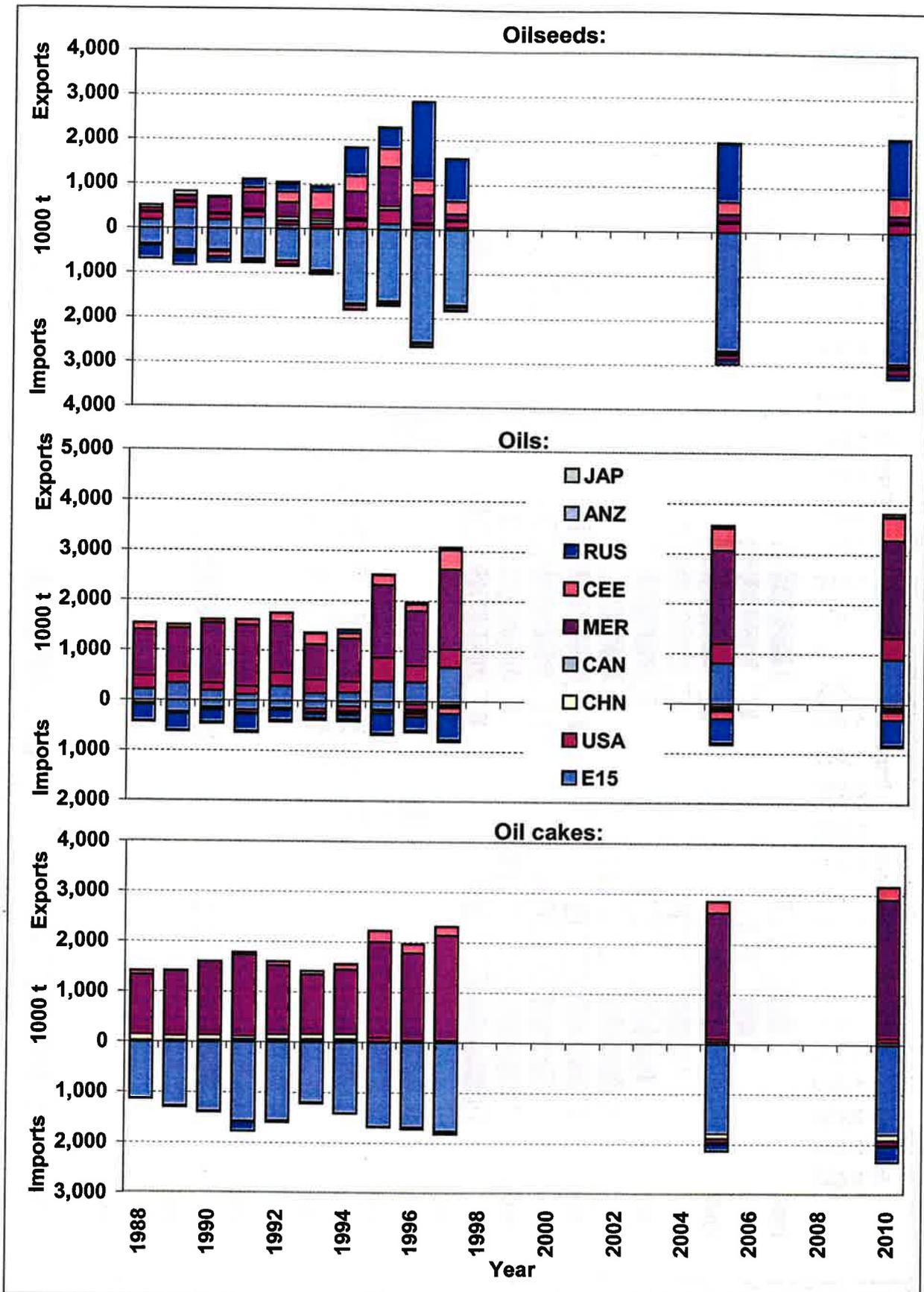
Russia, an important producer and the largest exporter of sunflower seed, is not expected to significantly recover from its depression in livestock production. Similarly, the crushing industry should be under pressure as well due to missing capital. Given a moderate increase in sunflower seed production (0.9% p.a. in average between 1997 and 2010), exports are projected to increase and to reach 1.3 mio. tonnes by 2005 and 2010. Sunflower oil exports, and cake imports, are projected to remain more or less unchanged at their 1997 levels.

Figure 5.16. Development of regional trade in the soybean complex, 1988-1997 and projection to 2010



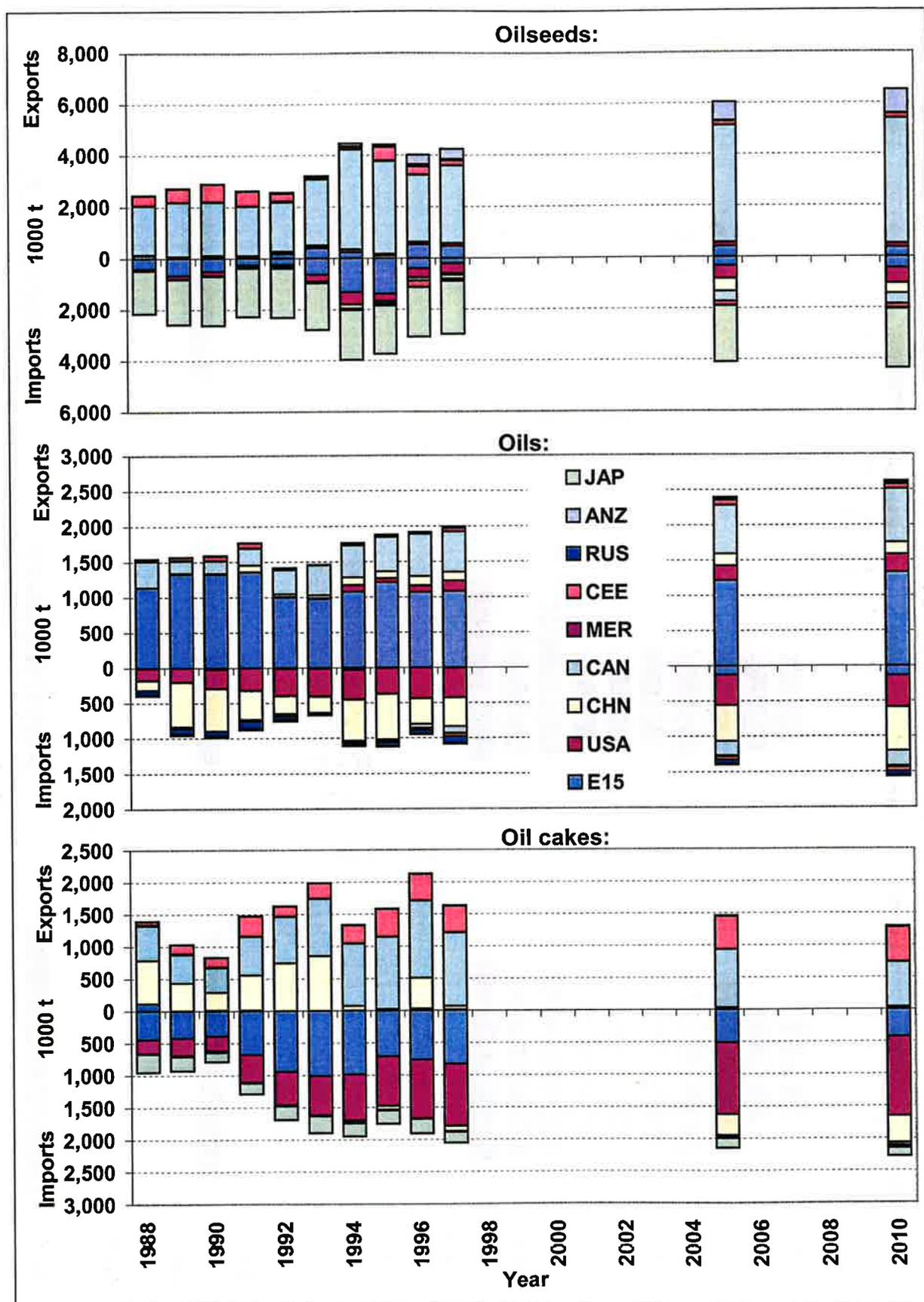
Source: WATSIM Data Base, WATSIM reference run. Trade may not add to zero due to ROW trade and statistical differences. Projections refer to net trade for markets indicated in Table 5.2.

Figure 5.17. Development of regional trade in the sunflower complex, 1988-1997 and projection to 2010



Source: WATSIM Data Base, WATSIM reference run.

Figure 5.18. Development of regional trade in the rape complex, 1988-1997 and projection to 2010

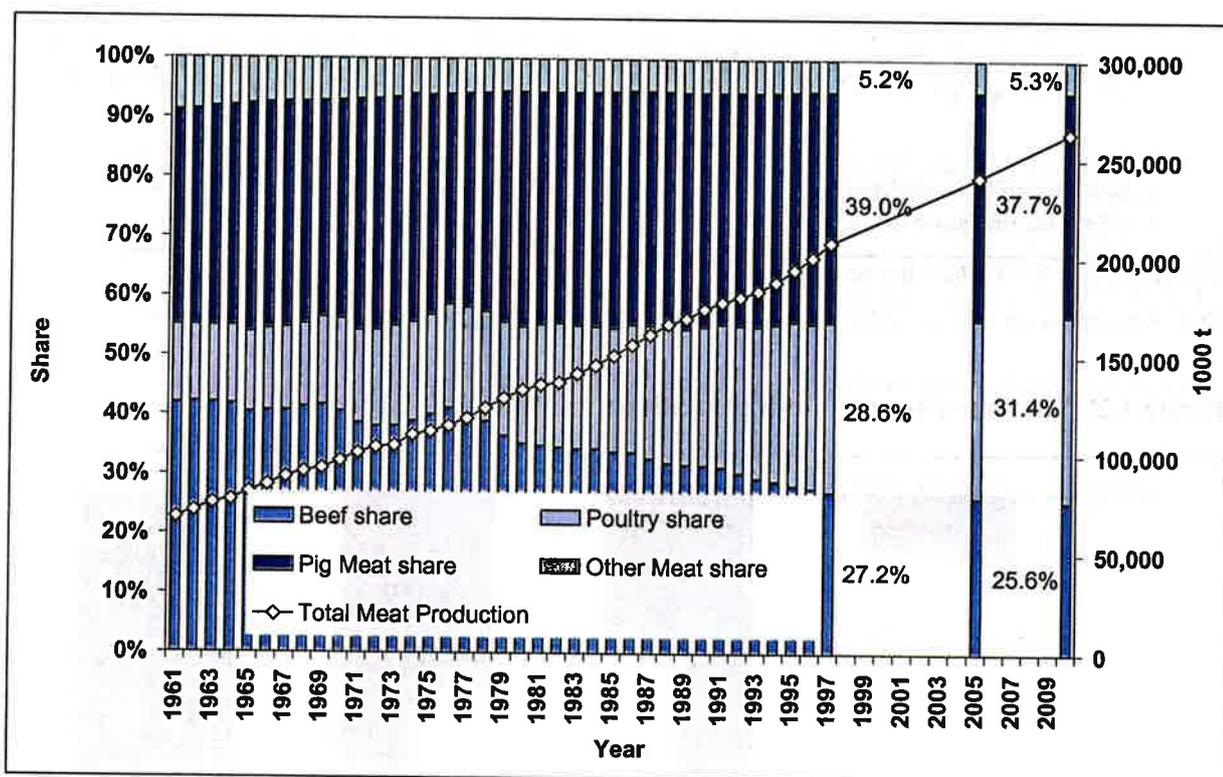


Source: WATSIM Data Base, WATSIM reference run.

### 5.4.2.3. Meat

Global meat production is projected to continue its strong growth, though at a somewhat more moderate speed, to reach 241 mio. tonnes in 2005, and some 263 mio. tonnes in 2010 (see Figure 5.19). While production of all types of meat is projected to increase significantly, most of the growth will be contributed by poultry meat both in relative and in absolute terms. Therefore, the poultry share in total meat will increase from below 29% in 1997 to well over 31% in 2010. The main loser among the meat types, though still increasing at 1.4% and 1.2% p.a. in the two intervals, is beef, the share of which is projected to drop from more than 27% to below 26%. Pig meat is projected to lose some of its share between 2005 and 2010, while other meat remains to play a minor role on the global scale.

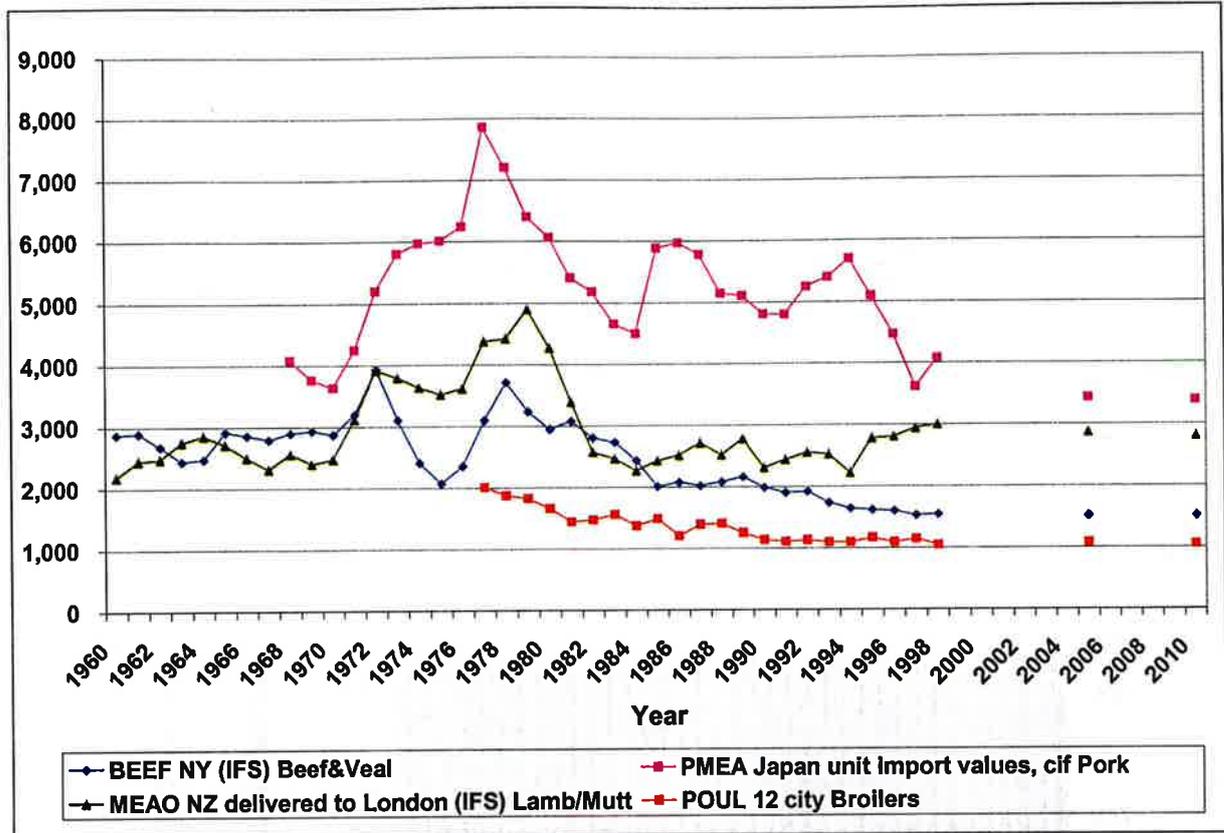
**Figure 5.19. Global meat production and shares of individual types of meat, 1961-1997 and projections to 2010**



Source: WATSIM Data Base, WATSIM reference run.

International meat prices are projected to decrease slightly slower in real terms than observed over the longer past (Figure 5.20). Real world market prices for pig meat, poultry and other meat should decline by an average of around 0.5% p.a., while those for beef is projected to be roughly constant (Figure 5.21). After inflation, however, all meat prices are expected to rise over the projection period.

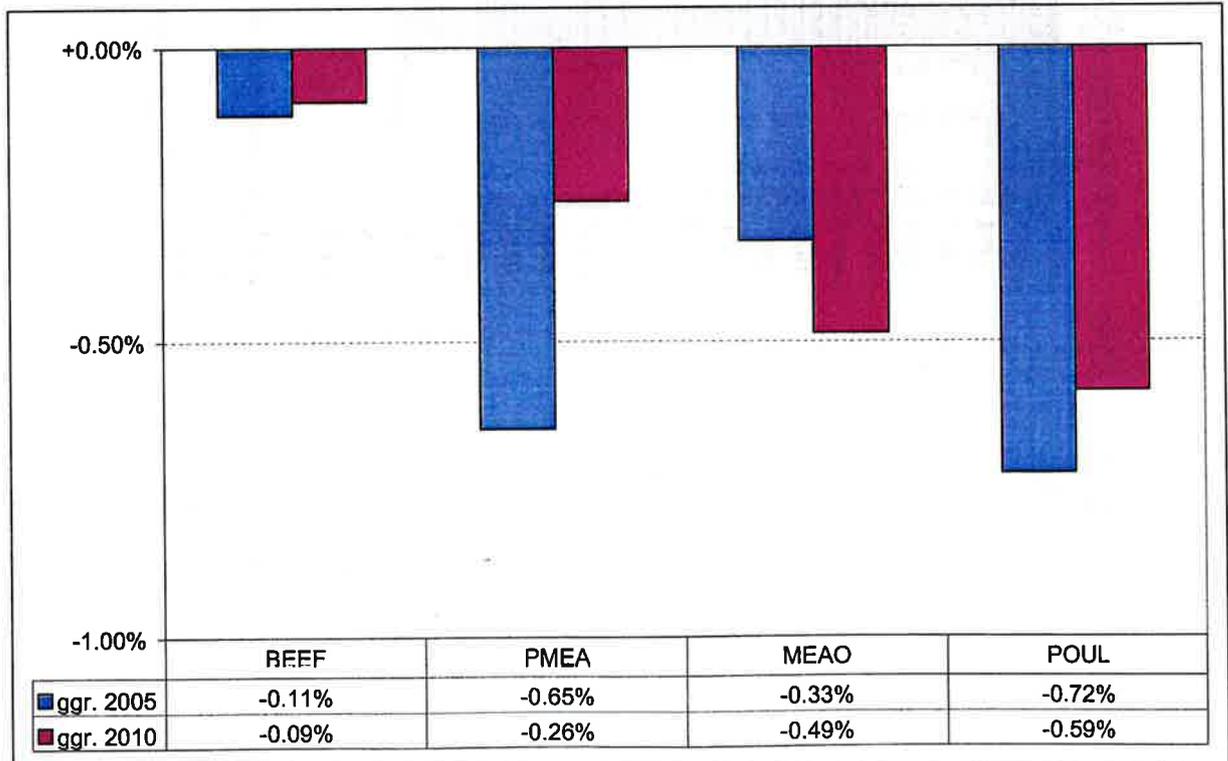
**Figure 5.20. International reference prices for meat, 1960-1998 and projections to 2010**



Source: USDA, WATSIM reference run.

Note: Projections are calculated from 1997 prices and simulated changes of real world market prices.

**Figure 5.21. Real world market price projections for meat, 1997-2010**

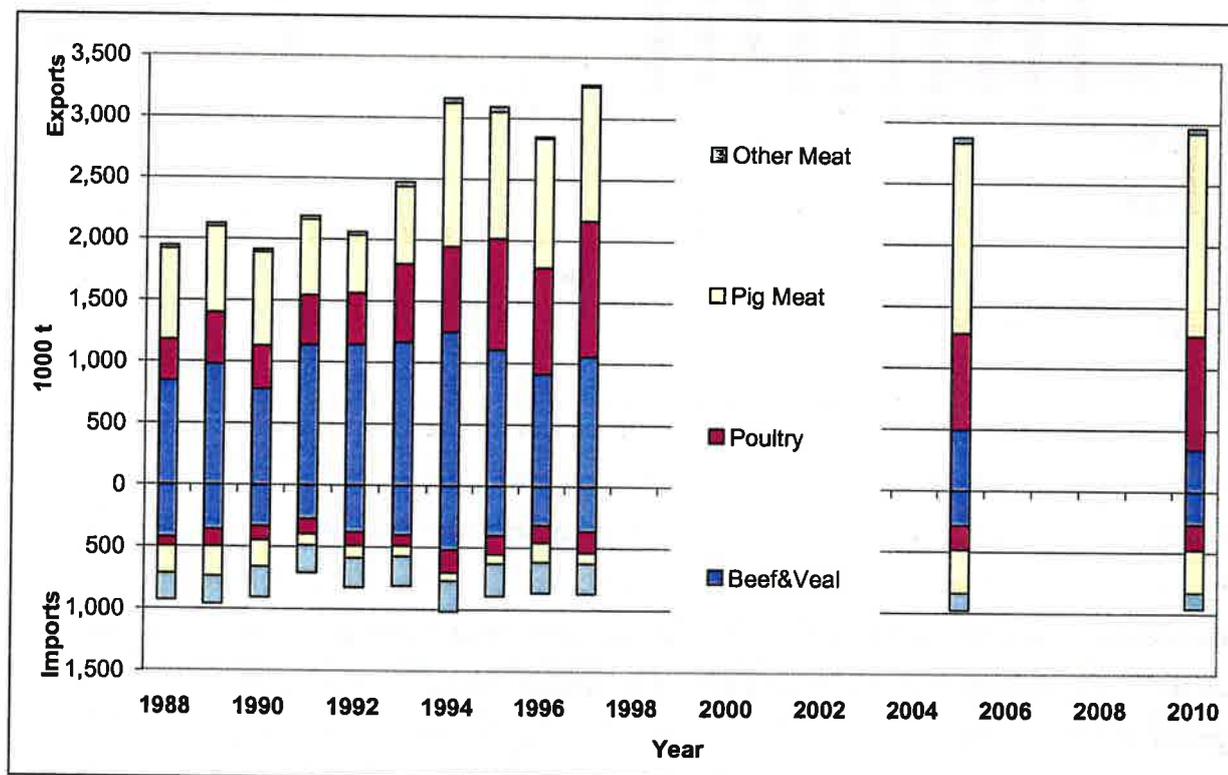


Source: WATSIM reference run.

At the regional level, the European Union, the United States and China represent the main meat producers, accounting for 59% of global meat production in the base year, and some 61% in 2010. With roughly 7% of global production, the Mercosur region is another important world producer. The Rest of the World aggregate accounts for some 23% of world's meat production.

In the European Union, growth in meat production is projected to slow down significantly, and to originate only from poultry and pig meat production. Production of ruminant meat, in contrast, is expected to decrease, particularly after 2005. Similarly, growth in meat consumption will focus on poultry and pig meat, while beef consumption is projected to increase only slightly in the first period due to price reductions in the context of the Agenda 2000 policy reform, and to decrease thereafter. Meat trade is projected to remain roughly at the 1997 level, while the trade structure should change (Figure 5.22). Beef exports are expected to decrease somewhat due to the decline in supply, meaning that the limit on subsidised exports would become unbinding in the medium term. Exports of pig meat, in contrast, are projected to expand with fairly favourable world market prices, allowing for an increase of the EU's world export share.

**Figure 5.22. Development of EU gross exports and imports of meat, 1988-1997 and projections to 2010**

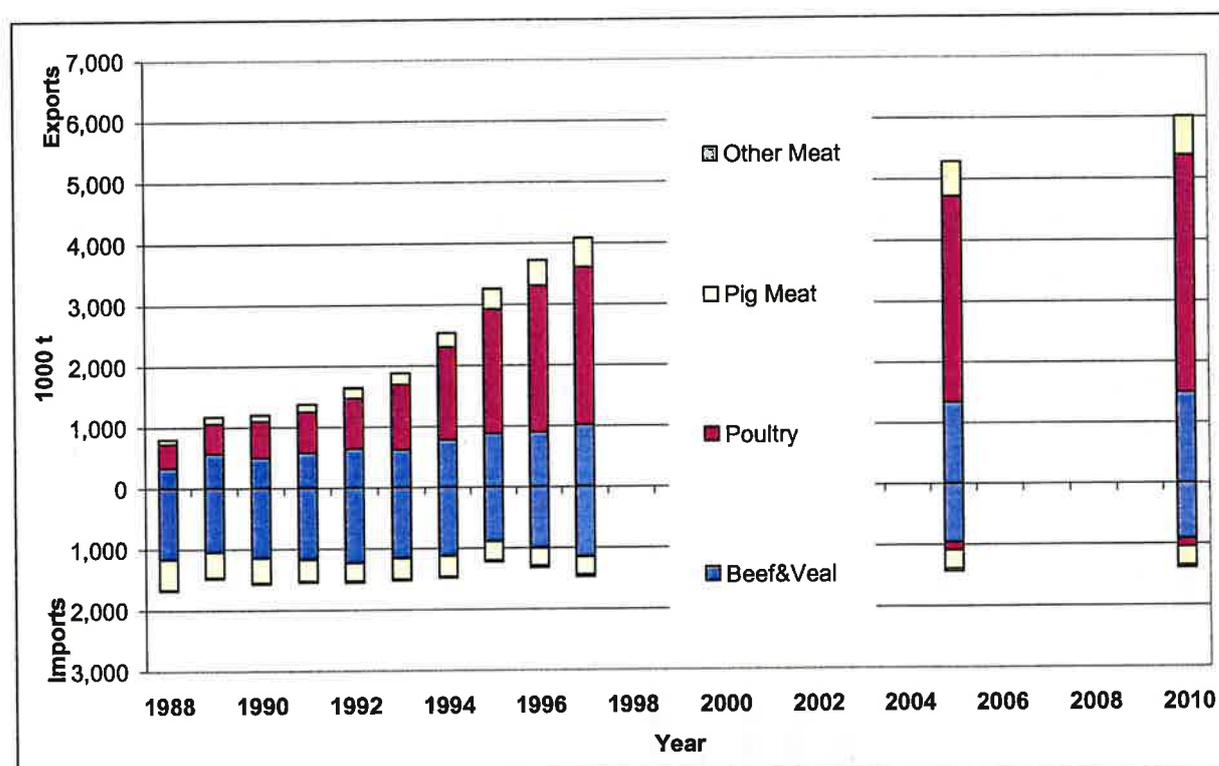


Source: WATSIM Data Base, WATSIM reference run.

For the US meat markets, the model projections indicate a somewhat stronger growth in total supply as compared to the EU, with an average of 1.5% p.a. between 1997 and 2005, and 1.2% between 2005

and 2010. More than two thirds of the additional meat supply will come from poultry production, and most of the remainder (particularly over the first sub-period) from pig meat production, while beef supply will grow at a more moderate pace with some 0.6% p.a. over the projection period. Even though meat demand in the US will increase as well, the meat trade is projected to show a significant growth in exports, particularly in poultry meat, but also in beef and pig meat (Figure 5.23), whereas imports are unlikely to change very much.

**Figure 5.23. Development of US gross exports and imports of meat, 1988-1997 and projections to 2010**

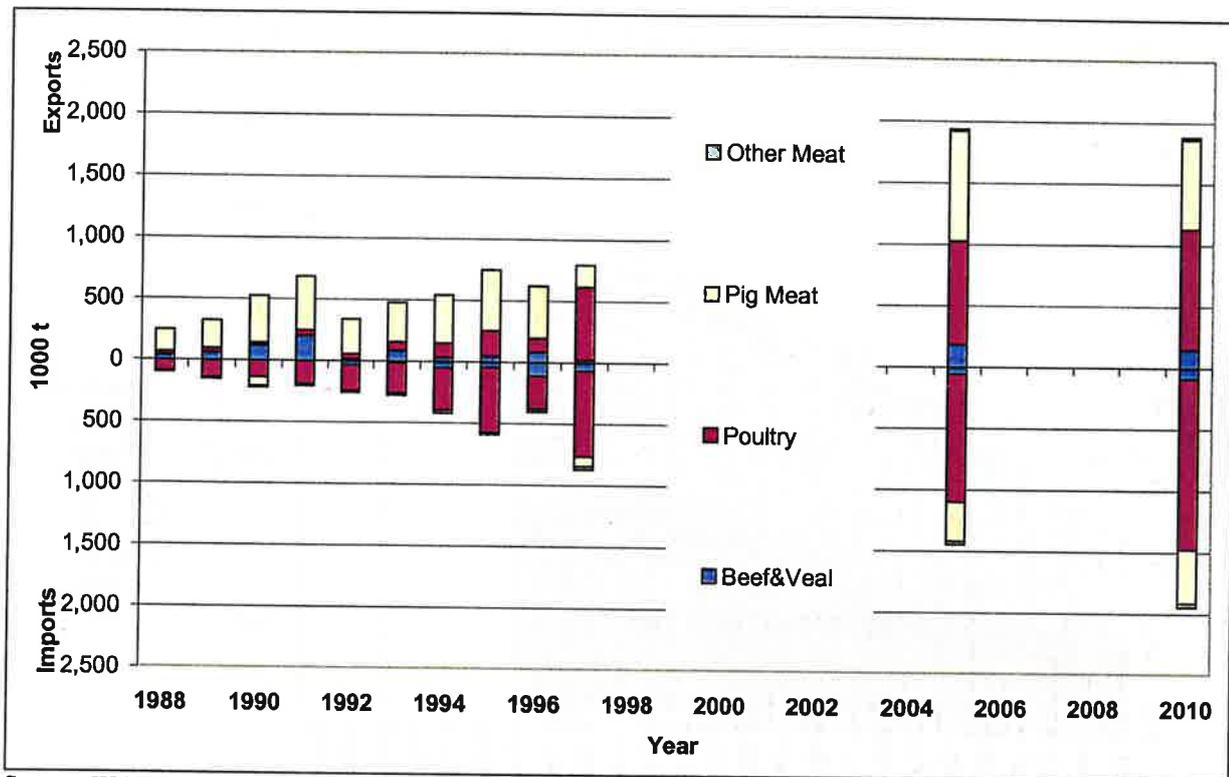


Source: WATSIM Data Base, WATSIM reference run.

World market developments strongly depend on the outlook for the Chinese markets, even though, in the past, foreign trade in meat was comparatively moderate. Meat supply in China is projected to continue its considerable growth, even though at a somewhat slower pace, with total output increasing by some 3.5% p.a. in average between 1997 and 2005, and 3.1% thereafter. While more than half of the additional meat will be pig meat, poultry and beef show the strongest growth in relative terms with up to 5% p.a. until 2005, and 4.7% and 3.2% p.a. between 2005 and 2010, respectively. This strong growth in Chinese meat supply should be followed by the domestic demand, triggered by economic growth and the increase in, particularly, urban population. Per capita meat consumption is projected to reach some 59 kg by 2010, up from 42 kg in 1997, and total meat demand will grow by some 3.4% and 3.2% p.a. in the two sub-periods, respectively. Consequently, Chinese meat trade is expected to expand somewhat on both the export and the import side, implying a slightly more open market to

trade in China (Figure 5.24). Increasing exports of pig meat are opposed to rising poultry imports, but given the size of the markets, trade quantities remain small.

**Figure 5.24. Development of Chinese gross exports and imports of meat, 1988-1997 and projections to 2010**



Source: WATSIM Data Base, WATSIM reference run.

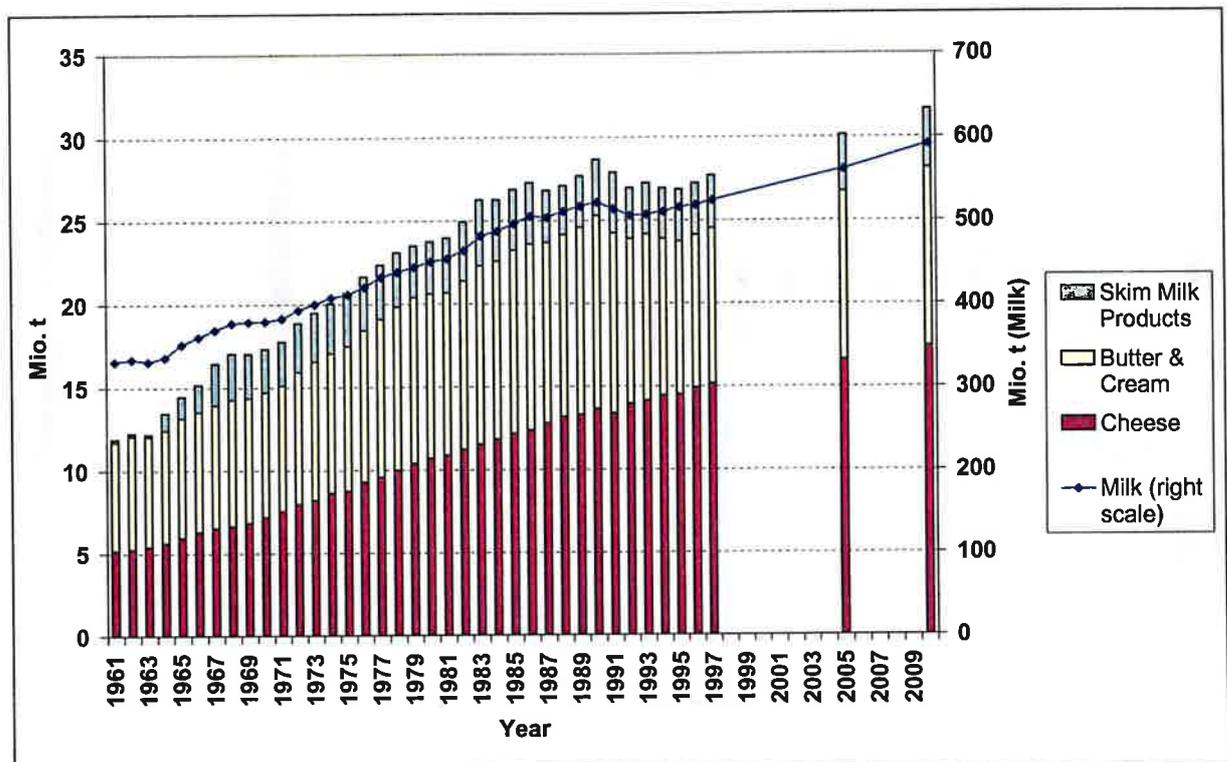
#### 5.4.2.4. Milk and dairy

Global milk production has seen considerable growth during the 1960s, 1970s and 1980s, but has slowed down significantly since the early 1990s due to two distinct factors. On the one hand, the introduction of the quota system in 1984 has stopped and partly reversed the growth path in the EU. On the other hand, the economic crisis after the break-down of the East block lead to significant reductions in milk production in the countries of the former Soviet Union and of Central and Eastern Europe. Milk production increasingly takes part in the Rest of the World aggregate, particularly in India. With growth in this region expected to basically follow the historical path, and production conditions particularly in Central and Eastern Europe to slowly recover, world milk production is projected to exceed 580 mio. tonnes in 2010 (see Figure 5.25).

An even more considerable growth can be observed in the production of processed milk products, particularly up to the mid-1980s, indicating a slower growth in the utilisation of fresh milk products. In WATSIM, these processed dairy products are represented in three categories: cheese, butter & cream, and skim milk products. With a production share of 43% in cheese, 36% in butter & cream, and

39% in skim milk products, and similar shares in world demand, the European Union is by far the largest world producer and consumer of these commodities, followed by the US for cheese and skim milk products. Even though Australia & New Zealand have a high share in global production only for skim milk products (15%), this region represents the largest exporter of dairy products. The largest importer is the Rest of the World aggregate.

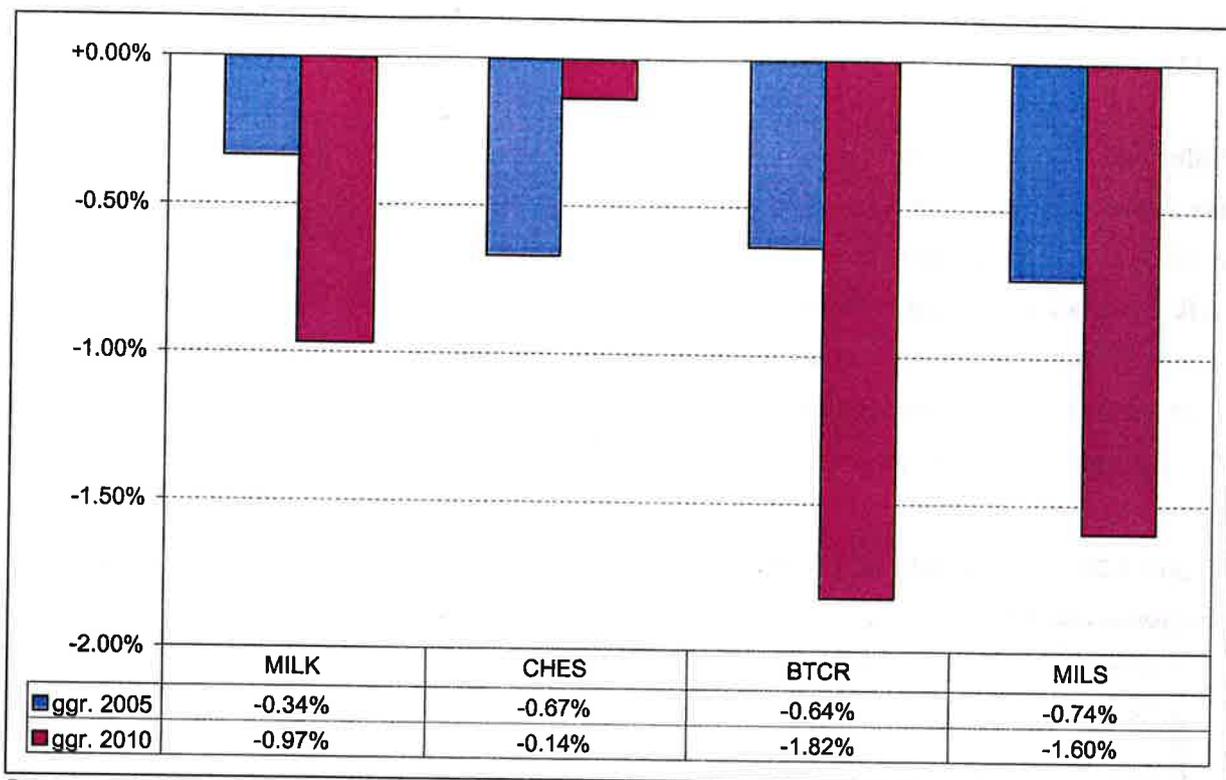
**Figure 5.25. Global production of milk and milk products, 1961-1997 and projection to 2010**



Source: WATSIM Data Base, WATSIM reference run.

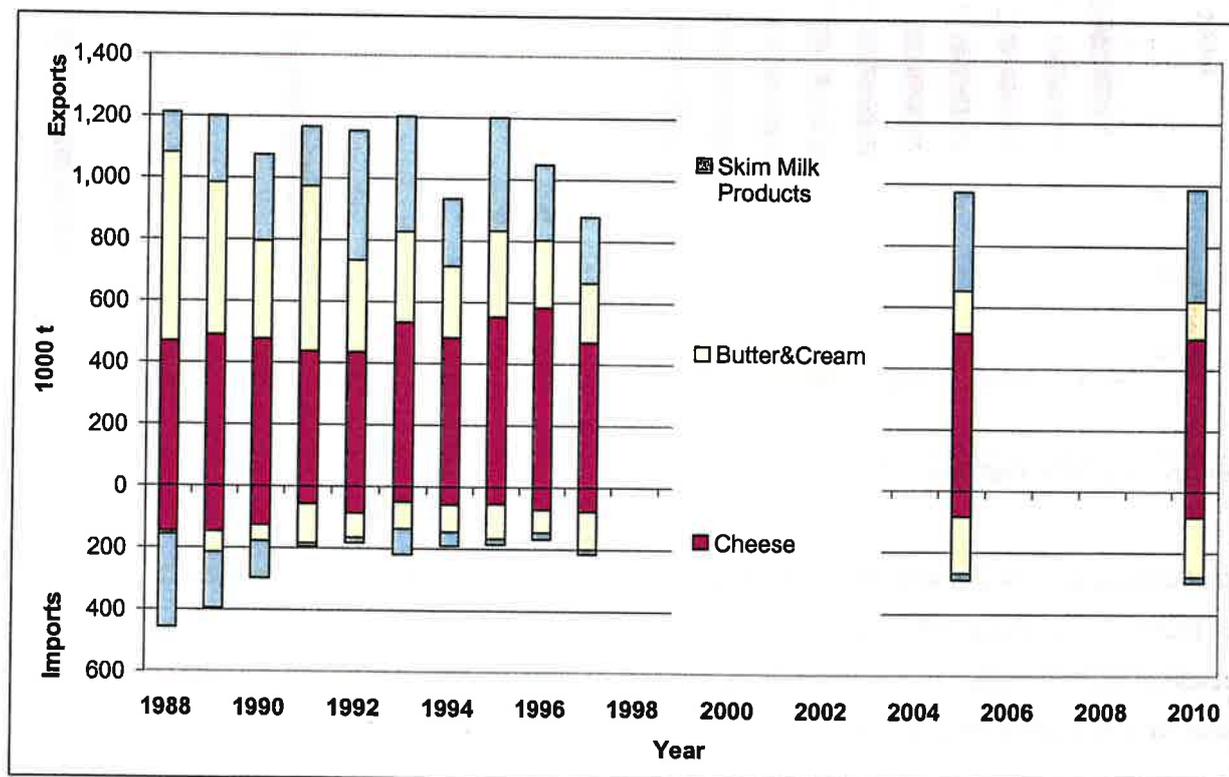
International prices for dairy products are projected to decline slightly in real terms, with average rates of  $-1.1\%$  p.a. for butter & cream, and skim milk products, and  $-0.5\%$  for cheese (Figure 5.26). With these rates, development of world market prices of dairy product is comparable to that of meat prices and more favourable than those for most crop products.

**Figure 5.26. Real world market price projections for milk and dairy products, 1997-2010**



Source: WATSIM reference run.

**Figure 5.27. Development of EU gross exports and imports of dairy products, 1988-1997 and projections to 2010**



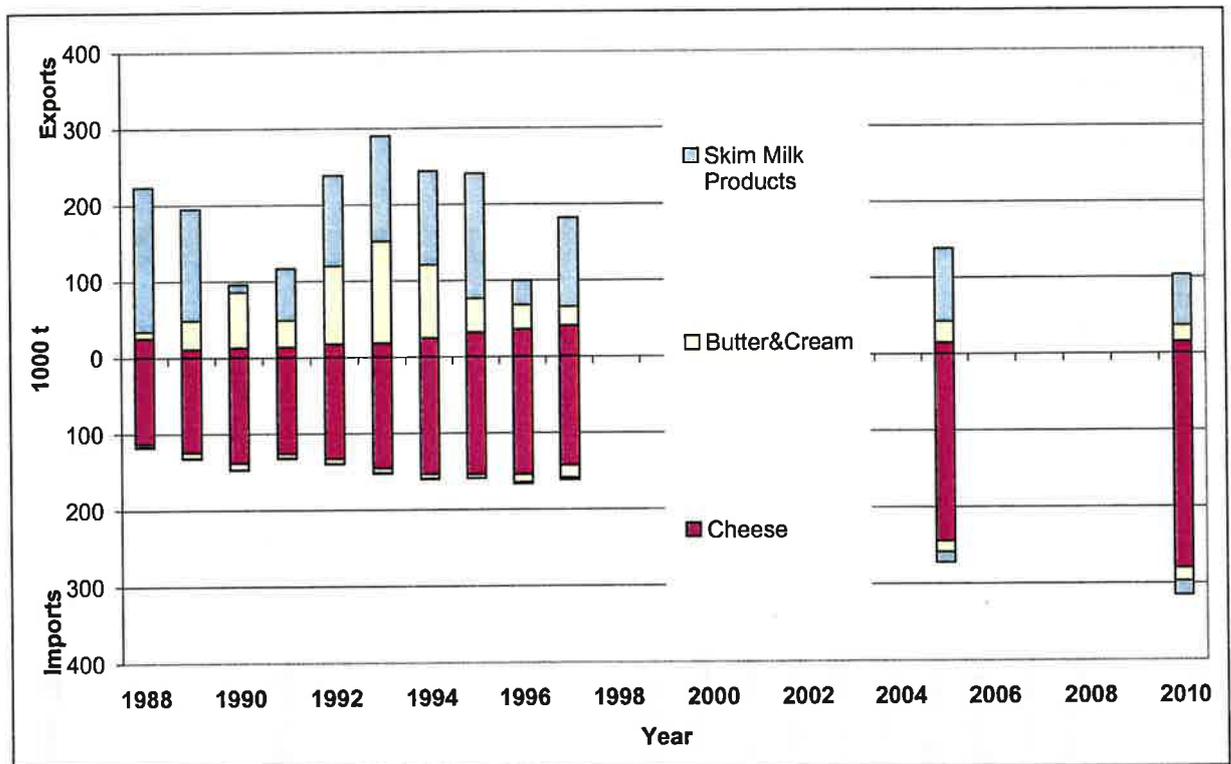
Source: WATSIM Data Base, WATSIM reference run.

Due to the quota system, milk production in the European Union is basically fixed, accounting for only the expansion of the EU milk quota and the increase of average fat and protein content. EU

supply and demand of dairy products, particularly cheese, are projected to increase slightly given the quota expansion. Foreign trade of dairy products, however, is not expected to change much (Figure 5.27).

Milk production in the United States is projected to continue its moderate expansion that this country has experienced since the mid-1970s, growing with an average 1% p.a. With 1.9% p.a., cheese production is projected to increase more significantly, while production of butter & cream and skim milk products are expected to decline slightly. This corresponds to the development of US demand for cheese and butter & cream, whereas skim milk demand is also projected to increase slightly resulting from the growth in livestock production. Consequently, exports of skim milk products are projected to decline, while particularly cheese imports are to expand significantly (Figure 5.28).

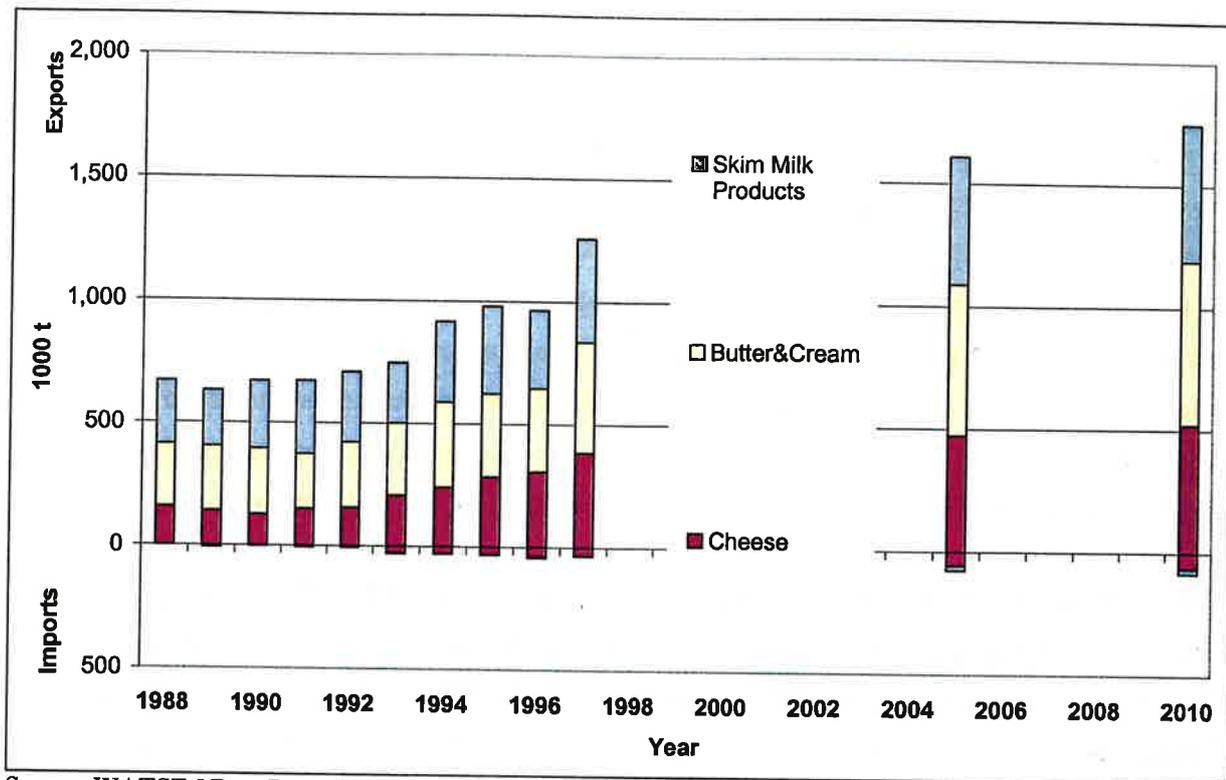
**Figure 5.28. Development of US gross exports and imports of dairy products, 1988-1997 and projections to 2010**



Source: WATSIM Data Base, WATSIM reference run.

In Australia & New Zealand, most of the dairy production is for exports, while domestic consumption is limited. Milk production is projected to show a continuous growth with above 2% p.a., and similar rates for dairy products. With only 40% of production used by domestic demand of cheese, and even less for other dairy products, most of the additional production will be exported (Figure 5.29). The region will therefore strengthen its position as the largest dairy exporter in the world.

**Figure 5.29. Development of gross exports and imports of dairy products in Australia & New Zealand, 1988-1997 and projections to 2010**



Source: WATSIM Data Base, WATSIM reference run.

#### **5.4.3. The WATSIM reference run under an alternative assumption on the degree of decoupling of area and headage payments in the EU**

The reference run generally assumes that all compensatory payments in the European Union are coupled to production. Even though they are coupled to harvested areas and livestock numbers, given the price-independent yield assumptions, this would translate to a price equivalent for each payment. The degree of (de)coupling of these payments cannot be determined within the WATSIM framework. However it is interesting to examine the extent to which the results of the WATSIM reference run are sensitive to the adopted (de)coupling assumption. Hence the reference run has been simulated under an alternative assumption about the degree of decoupling of EU area and headage payments. This alternative simulation of the reference run, called the "partial de-coupling" scenario, assumes a relative de-coupling rate of 50%, i.e., one € of compensatory payment per tonne in the target year is assumed to have the same impact on production as 50 Cents of a direct production subsidy.

Area payments are paid for cropping cereals, protein crops and oilseeds, whereas sugar and starchy products (potatoes) do not benefit from these payments. While payments for cereals have been increased in the context of the Agenda 2000 reform package, payments for oilseeds, that were significantly higher than those for cereals after the 1992 CAP reform, have been reduced to the cereal

level. Some higher payments are still in force for protein crops and for durum wheat.<sup>88</sup> Headage payments, on the other hand, are relevant for beef & veal production, for sheep and goat meat and, after the Agenda 2000, for milk.<sup>89</sup>

With respect to the basic reference run, modelling a partial (de)coupling of area and headage payments in principle can be considered as a reduction of (effective) payments for those commodities where payments are increased between base and target year (i.e., cereals, beef, other meat, and milk), and an increase of payments for those where payments are reduced (i.e., oilseeds). Consequently, the impact of the changed assumption with respect to the coupling factor on agricultural production in the EU is basically negative for cereals, beef & veal, and other meat, and positive for oilseeds, with some cross price effects on other commodities as well. Given that no policy changes are modelled between the target years 2005 and 2010, the impact of the partial de-coupling assumption is very similar across these two years. The following discussion will therefore focus on the final target year.

Among cereals, barley and wheat are simulated to be most sensitive to the level of coupling of the area payments. With payments only coupled by 50%, wheat production would increase much less than with full coupling, and barley supply would decline more significantly. Simulated wheat production in the "partial de-coupling" scenario is 3.6% lower than in the reference run by 2010, reaching only some 107 mio. tonnes instead of 111 mio. tonnes in the basic reference run. Similarly, barley production would be 5.2% below reference run level in 2010 and reach some 48 mio. tonnes instead of 50 mio. tonnes. Maize and other cereals react significantly less, with differences in 2010 being less than 1% between the reference run and the "partial de-coupling" scenario. This is probably due to the fact that wheat and barley production areas in the EU are more on the high-yield side, while regions where other cereals are predominant are generally less productive, resulting in lower area payments for the latter than for the former commodities.

Oilseeds, in contrast, would be better off under the partial de-coupling assumption: the reduction of oilseed payments implied by the Agenda 2000 reform would mean a smaller reduction of the incentives to produce oilseeds, as compared to cereals. In the "partial de-coupling" scenario, particularly soybean production would expand much stronger than in the reference run: EU supply would be some 14% above reference run level in 2010 – though still a minor crop in the EU. The other oil crops – sunflower seed and rape seed – respond more moderately, with changes in 2010 being 2% and less than 1% only, respectively, between the reference run and the "partial de-coupling" scenario. Again, the different reference yields in the EU regions may result in these differences across crops.

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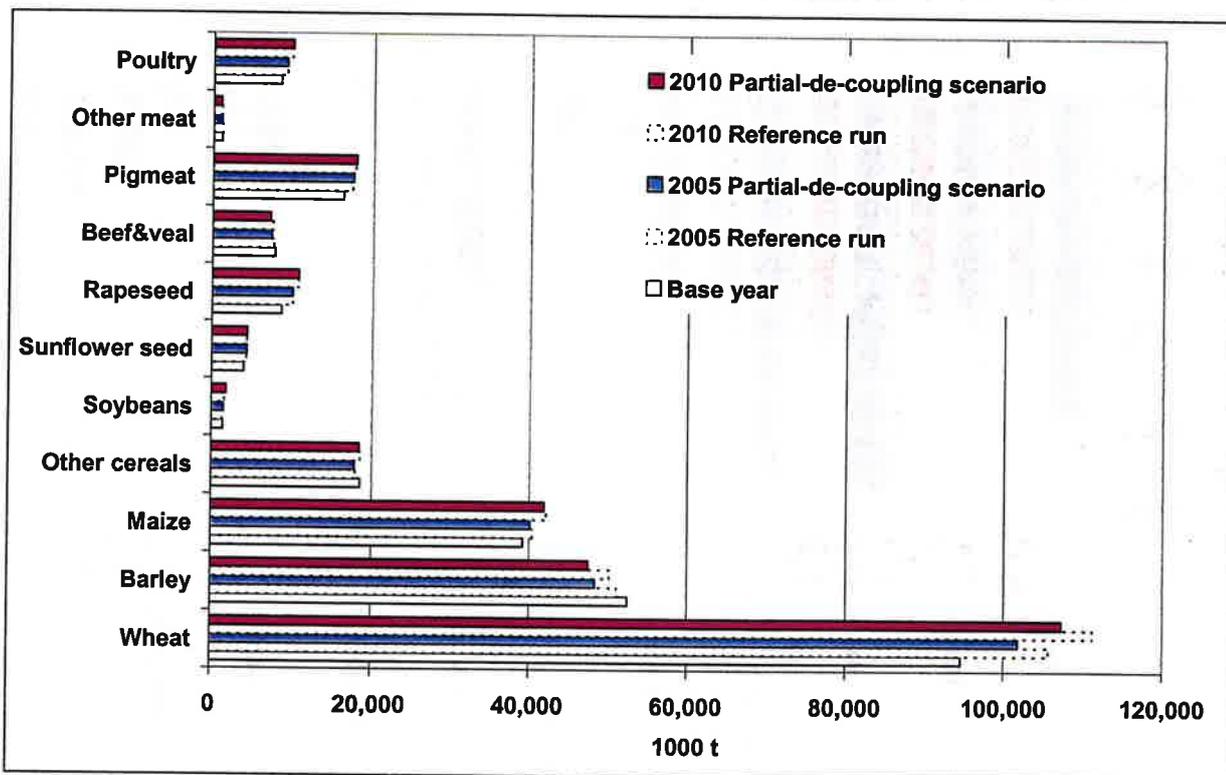
<sup>88</sup> Durum wheat is not represented separately in WATSIM.

<sup>89</sup> Note that due to the quota system, milk supply is not expected to respond to the cow premiums. Instead, these premiums as well are designed in terms of beef production.

Harvested areas for starchy products, i.e., primarily potatoes in the EU, and hence production, would be reduced more slowly in the "partial de-coupling" scenario, with production simulated to be 1% above reference run level in 2010.

On the livestock side, beef & veal, and other meat (i.e., sheep and goat) would see significant impacts: the decline in the beef production would be stronger in the "partial de-coupling" scenario, with supply in 2010 being some 4% below baseline level. Similarly, production of other meat would decline already in the first sub-period, and supply would be 5% below baseline level in 2010. On the other hand, production of non-ruminant meat would see an even stronger expansion, with poultry production in 2010 being almost 2% above baseline level, while pig meat production would be 0.7% higher. The corresponding figure for the eggs production is 0.5%. Projections for the EU cereal, oilseed and meat production under both assumptions on the degree of decoupling of area and headage payments (i.e., coupling vs partial de-coupling) are presented in Figure 5.30 below.

**Figure 5.30. Development of cereal, oilseed and meat supply in the EU under different assumptions on the degree of de-coupling of area and headage payments, 1997-2010**

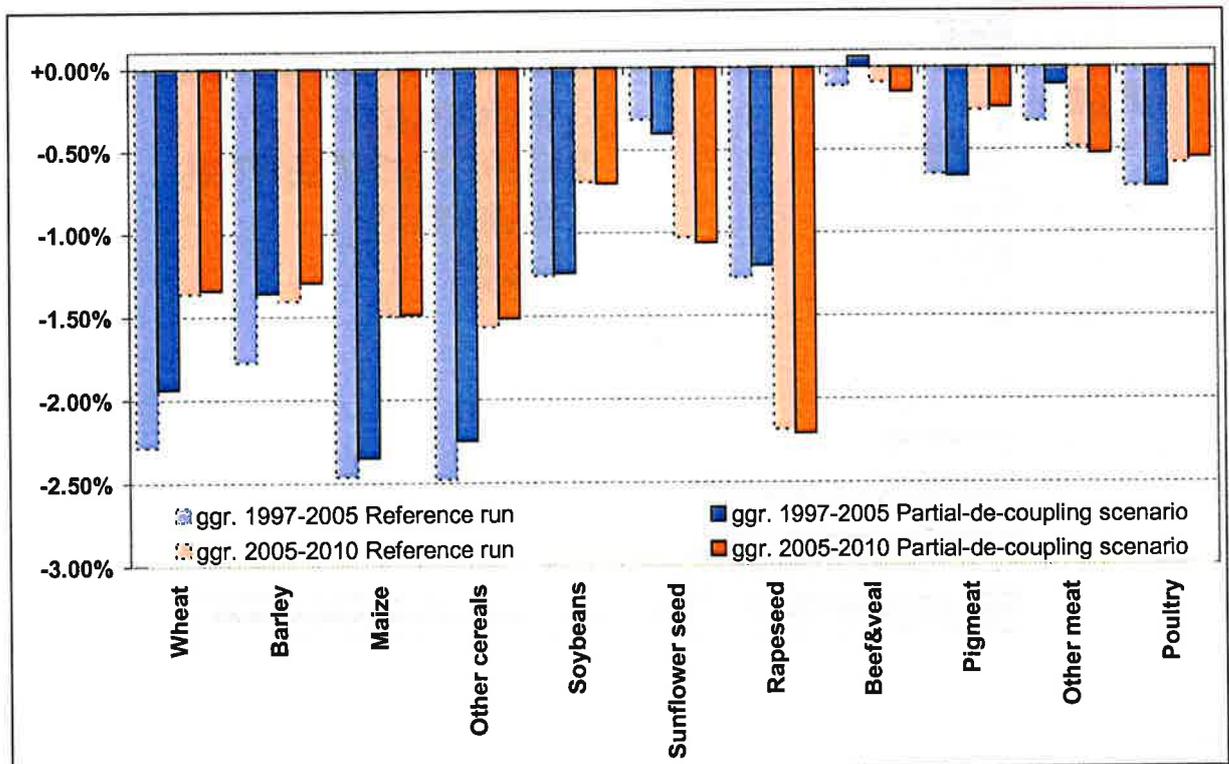


Source: WATSIM simulation results.

Given the higher EU meat production, overall domestic feed demand would be slightly higher, particularly feed use of corn, other cereals, and oil cakes, would be higher than in the reference run. In contrast, the use of wheat would be below baseline level due to higher wheat prices.

International prices would develop slightly differently than in the reference run. Due to the reduced domestic supply, EU wheat exports would be some 2.4 mio. tonnes below baseline level, and an additional 0.7 mio. tonne would be imported, pushing international prices well above reference run level. By 2010, world market prices would be almost 3% higher in the "partial de-coupling" scenario than in the reference run, changing the average geometric growth rate (ggr.) by some 0.2 percent points. Barley prices would be 4% higher, or 0.3 percent points in the ggr. Due to the large import share of the EU, oil cake price would also be higher by between around 1 to 3% (up to 0.26 percent points in the ggr. of other oil cakes). Meat prices are significantly less sensitive with the exception of other meat, which would be almost 2% more expensive in 2010 than under baseline conditions (0.1 percent points) (Figure 5.31).

**Figure 5.31. Development of real world market prices for cereals, oilseeds and meat under different assumptions on the degree of de-coupling of EU area and headage payments, 1997-2010**



Source: WATSIM simulation results.

A further significant impact of the partial de-coupling assumption of EU area and headage payments is that the UR limits on subsidised exports would no longer be binding for barley. With 8.7 mio. tonnes and 8.3 mio. tonnes in 2005 and 2010, respectively, EU barley exports are well below the UR

commitment level in the "partial de-coupling" scenario. Structural intervention purchases become, therefore, unnecessary under these circumstances.

## **5.5. The impacts of further liberalisation of agricultural markets**

### **5.5.1. The WTO scenario**

The second scenario focuses on possible further steps in the trade liberalisation process. The last WTO multilateral agreement as far as agriculture is concerned, the Uruguay Round Agreement on Agriculture (URAA), committed the member countries to the following policy changes<sup>90</sup>:

- Tariffication of all border measures, and reduction of tariffs by 36% in average, with a minimum of 15% for each tariff line.
- Provision of a minimum market access, often realised by tariff-rate quotas.
- Reduction of domestic support (the Aggregate Measure of Support, AMS) by 20%.
- Reduction of export subsidies by 36%, and of subsidised export quantities by 21%.

Furthermore, the agreement included the continuation of the liberalisation process by means of new multilateral negotiations, which are currently under way. While the final outcome of these negotiations, lead by the WTO, is still unknown, a scenario similar to the URAA outcome has been simulated with WATSIM to analyse possible impacts on regional and global agricultural markets. In particular, the following assumptions were applied in the WTO scenario<sup>91</sup>:

- A further reduction of remaining tariffs (or MFN tariffs on markets with tariff-rate quotas) by 36%.
- An expansion of tariff-rate quotas by 50%.
- A further reduction of all domestic support measures by 20%.
- A further reduction of the limits on subsidised exports in value and volume by 36% and 21% respectively, with the level of export subsidies per unit of exports reduced according to the tariff reduction.

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<sup>90</sup> Basis for the reduction commitments was the period 1986/88, unless measures were higher on 1 January, 1995.

<sup>91</sup> Note that all policy changes are assumed to be in force already in 2005, with no further policy shifts occurring between the target periods.

### ***5.5.2. Impacts of further liberalisation on agricultural markets***

Impacts of the WTO scenario on agricultural markets are particularly significant in regions with high border measures, such as Japan.

International market prices of grains show the most significant impact for barley, which prices would be 6.8% higher in 2010 under more liberalised markets than in the reference run (Figure 5.32). This is particularly due to the tightened commitment on subsidised EU exports (already constraining in the reference run), resulting in barley exports by this region to be 6.4 mio. tonnes in both 2005 and 2010, instead of 10 mio. tonnes as in the reference run. Consequently, barley intervention purchases in the EU would be 4.1 mio. tonnes in 2005 and 3.6 mio. tonnes in 2010 in the WTO scenario, instead of 1.1 mio. tonnes and 0.6 mio. tonnes in the reference run.

On the other hand, given increased imports due to reduced tariffs, particularly in Japan where grain imports are some 0.7 mio. tonnes above reference run level in 2010, and also cross price effects in supply and demand, world market prices for wheat, maize and other cereals would be between 1% and 2.2% above reference run level under the WTO scenario.

Under more liberalised markets, the world pig meat price in 2010 would be 1% higher, compared to the reference run, while other meat prices would be around 0.2% higher than corresponding reference run levels. International meat prices are particularly influenced by the impacts of the WTO scenario in Japan. Under more liberalised conditions, the Japanese pig meat and poultry meat imports would be, respectively, 9% and 2% higher in 2010 as compared to the reference run (corresponding to additional 0.11 mio. and 17 000 tonnes respectively). Similarly, pig meat and poultry imports by Central and Eastern Europe would be some 23 000 and 6 000 tonnes higher, respectively, in 2010, while in the same time exports of both types of meat would be reduced by 23 000 and 16 000 tonnes, respectively. On beef markets, a slight reduction of EU and Canadian exports would also cause the world price to be higher under the WTO scenario than in the reference run.

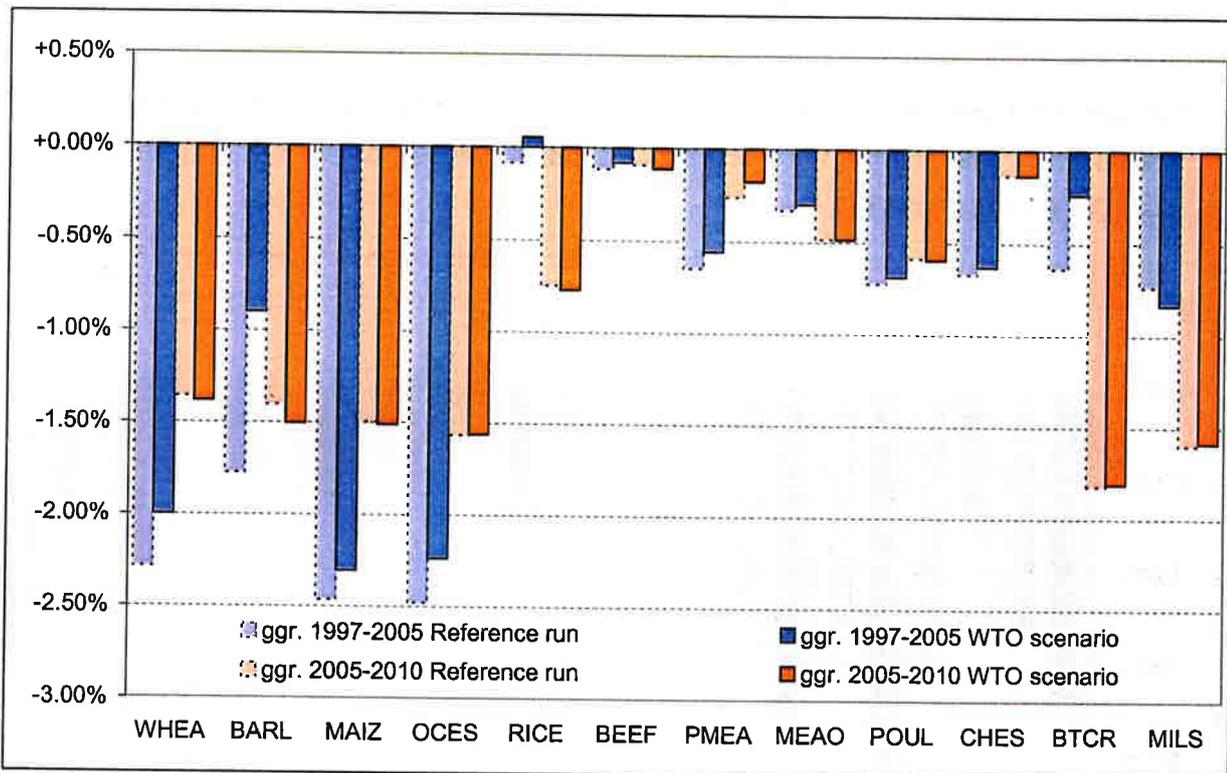
On milk markets, the most important change following the WTO scenario would be the increase in the tariff-rate quotas for cheese, butter & cream, and skim milk products in the EU. Particularly for butter & cream, the increase in EU imports (+61 000 tonnes), only partly compensated by additional exports (+22 000 tonnes), causes international prices in 2010 to be more than 3% above reference run levels. For cheese, the increase in EU imports (+32 000 tonnes) is almost completely compensated by additional exports (+30 000 tonnes), dampening the impact on international prices.<sup>92</sup> The impact of

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<sup>92</sup> It is interesting to note that, given the virtually unchanged international prices, none of the other regions significantly increases its exports. This might be interpreted by arguing that any third country's exports going to the EU under the expanded quota might reduce that country's exports to other regions, leaving its total cheese exports more or less unchanged. It is, however, also a problem in the model methodology in that the Armington

the WTO scenario on skim milk markets, where international prices in 2010 are slightly lower than in the reference run, is caused by the interrelationship between skim milk products and butter & cream: given the higher butter prices, supply of both commodities is increased, putting pressure on the skim milk prices. The expansion of the EU tariff-rate quota for skim milk powder has no effect on the results due to the fact that the applied in-quota tariff (i.e., 475€/t) is already relatively high, and the quota (68 000 tonnes) is significantly under-filled in the base year (16 000 tonnes).

**Figure 5.32. Development of real world market prices for cereals, meat and milk products under the reference run and the WTO scenario, 1997-2010**



Source: WATSIM simulation results.

### 5.5.3. The WTO scenario under the assumption of partial de-coupling of area and headage payments in the EU

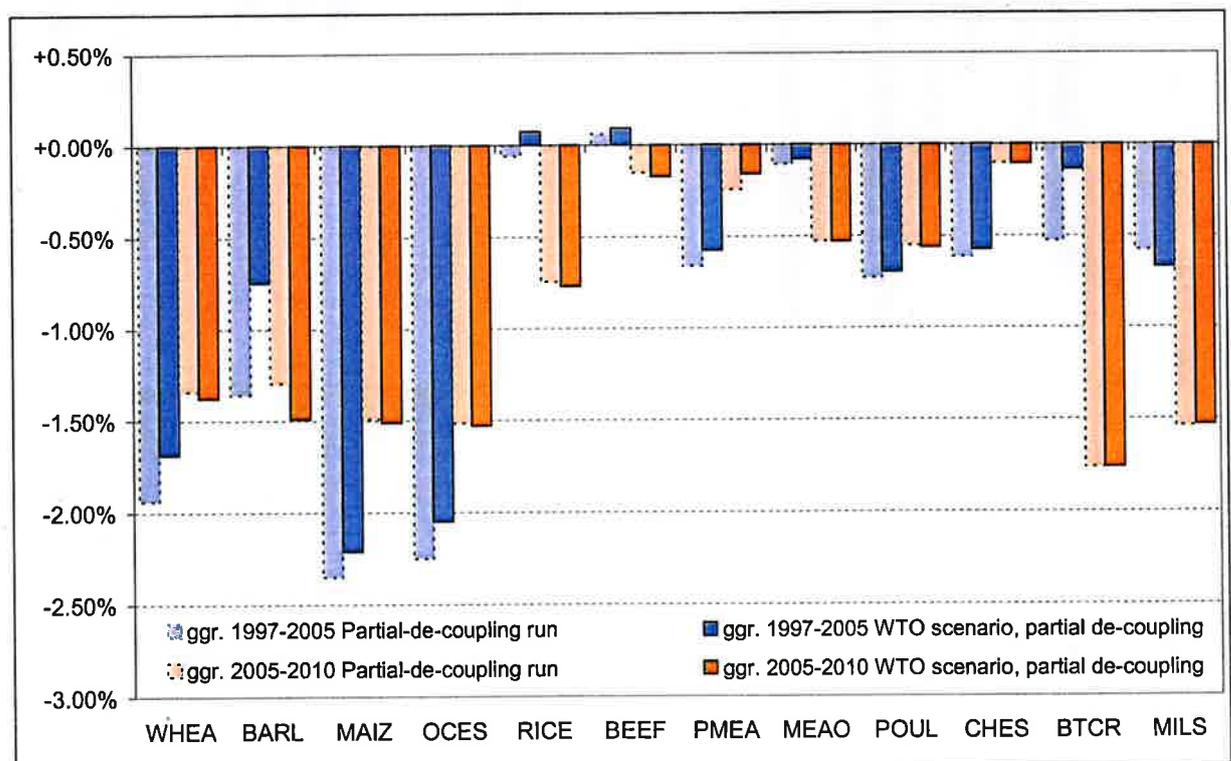
If the compensatory payments in the EU are assumed to be only partially effective on supply (see paragraph 5.4.3), the above described principal impacts of the WTO scenario would not be substantially modified.

approach is simplified to represent only gross trade, but no bilateral trade flows. Not only can the source of the additional cheese imports to the EU not be identified by this concept, but its theoretical weakness might lead to the interpretation that the EU now "imports its own exports".

Given that under the partial de-coupling assumption, subsidised EU barley exports would not longer be bound by the WTO limits, the effective reduction of these exports would be 1.9 moi. tonne smaller than under the full coupling assumption. Consequently, the impact on the world barley price would be, in 2010, a 4% increase only, with respect to the reference run level, instead of a 6.8% increase (Figure 3.33). The impact on international wheat, maize, other cereals and rice prices would also be smaller than under the full coupling assumption.

The impact of the WTO scenario on meat and dairy markets is largely the same under alternative assumptions regarding the degree of decoupling of EU area and headage payments, with price effects being slightly smaller under partial de-coupling than under full coupling.

**Figure 5.33. Development of real world market prices for cereals, meat and milk products under the the Refernce Run and the WTO scenario, assuming partially de-coupled area and headage payments in the EU, 1997-2010**



Source: WATSIM simulation results.

## 5.6. Conclusion and policy recommendations

The aim of the WATSIM-related tasks in this project was to improve both the WATSIM Data Base and the simulation model in order to allow for better reflection of policy-relevant issues on agricultural markets. The Data Base has been updated and extended, in that in addition to the existing Non-Spatial Data Base (NSDB), a Spatial Data Base has been constructed to reflect bilateral trade flows across the model regions. The United Nations' COMTRADE data base was used and consistency both within the

SDB and between SDB and NSDB was achieved due to a calibration process, making use of a cross-entropy approach.

The simulation model has been modified in particularly two aspects. Firstly, the general net-trade concept has been abandoned, and a modified Armington approach was used to represent gross imports and exports simultaneously. Then, based on this gross trade approach, the second step was to properly consider a broad set of trade related policy measures. In addition to import tariffs and limits on subsidised exports, that were incorporated already in the net-trade model, but are portrayed much more realistically in the gross trade model, the concept of tariff-rate quotas (TRQs) has been included to take UR market access commitments into account. Due to restrictions in the data availability during the project phase, TRQs are actually included only for three markets, i.e. the EU markets for milk products, but additional TRQs can be considered basically by adding the respective data, since the model formulation is generally symmetric with respect to all markets. In addition to the trade related measures, domestic support is also considered in detail by the model. Different assumptions with respect to the degree of (de)coupling of specific measures can be made by simply changing parameters.

The WATSIM reference run indicates that international markets for agricultural commodities should recover only slowly from the depression of the recent years. With average changes between  $-1.8\%$  and  $-2.5\%$  p.a. from 1997 to 2005, real world prices for cereals are projected to develop only slightly more favourable than in the past. However, this is partly due to still relatively high prices in the 1997 base year (though already well below the 1995 peak). Between 2005 and 2010, prices are projected to develop more favourable. Sensitivity analyses with respect to the Armington parameters (i.e., the elasticities of substitution and of transformation) have shown a relative robustness of the reference run results.

Assuming a partial de-coupling of EU area and headage payments, however, results in quite interesting differences as compared to the basic reference run. If payments are coupled to production only by 50%, EU production of wheat and barley after the Agenda 2000 reform would be significantly lower than under the basic reference run assumptions, whereas supply of oilseeds (particularly soybeans) would be higher. Similarly, the production of ruminants would be smaller in contrast to the production of pig meat, poultry meat and eggs. It seems important to note that, given a partial de-coupling of these payments, the excess supply of barley would be below the limit on subsidised exports, thus eliminating the need for intervention purchases both in 2005 and 2010.

A further step in the liberalisation process, as could be assumed as an outcome of the current WTO negotiations, would allow international prices to develop more favourable. Here, the reduction of subsidised EU barley exports, the expansion of EU tariff rate quotas for milk products, and the

decrease of tariffs in highly protected regions such as Japan on the other hand, would result in higher world market prices. This impact is particularly strong for barley, but is significant also for butter & cream and for cereals in general. For the EU, given unchanged domestic policies, this would result in significantly increased intervention purchases of barley, both in 2005 and 2010.

In principle, the impact of the liberalisation scenario is changed only slightly, if compensation payments in the EU are assumed to be partially de-coupled. Price effects are, however, somewhat smaller, particularly for barley, where the reduction in exports would be less significant. In any case, however, the model results for the liberalisation scenarios indicate some pressure on the EU to change domestic policies, in order to avoid significant amounts of barley to be purchased for intervention stocks.

The WATSIM model has proved to be a useful tool for the analyses of agricultural markets and policies. It still has, however, some weaknesses that require further research and development. To increase the usefulness of the model for the EU decision makers, further topics like the enlargement to Central and Eastern Europe have to be considered. Similarly, the Free Trade Area of the Americas may become relevant in near future. Consequently, the WATSIM model needs to be able to capture regional trade agreements, simulations of which are not possible with the current system.

The overall outcome of model results has proven to be relatively robust with respect to alternative assumptions on the elasticities of substitution and of transformation. Specific trade developments, however, may well be influenced by changes in the parameters, which are not very soundly justified in the current model. Further research is necessary to identify the empirical parameters, and to test whether the assumption on limited substitution and transformation is justified for agricultural commodities. In addition to that, it is important to note that the simplification of the original Armington approach, assuming that limited substitution exists between domestic and imported goods while substitution across imports from different origins is assumed to be perfect, to a certain degree lacks theoretical consistency. On the one hand, the approach draws on the assumption that there are some kind of quality differences between domestic and imported commodities of the same type, and similarly between domestic and export sales. On the other hand, however, the concept of a spot world market assumes homogeneity of the commodities, given that there is only one price (index) relevant for all quantities exported to or imported from this spot market. Clearly, there is some contradiction. Further research is necessary that may eventually lead to a fully spatial representation of international trade (i.e., the original Armington approach), or to a representation of gross trade different from the Armington approach.

Finally, while the model structure allows to consider all types of policy measures for all regions symmetrically, data on actual policy is missing for a number of regions. The impact of administrated

trade barriers or of domestic policies, however, may be significant in developing countries as well. For example, policy measures in China may well influence both domestic and international markets. Further research is necessary to reflect actual policies in all regions both in the data base and in the simulation model.

## APPENDIX 1.

### **Sensitivity analysis: Sensitivity of the model outcomes with respect to the values of the elasticities of substitution and of transformation**

One of the most important questions in terms of the application of the Armington approach in a trade model is how to obtain appropriate parameters to fill the functional relationships. In particular, there are three sets of parameters necessary for the CES demand functions and the CET supply functions, including the elasticities of substitution and transformation, respectively, the distribution parameters and the scaling parameters. Given that the sum of distribution parameters must equal unity, there are thus three parameters to find for each region and commodity and each of the supply and demand sides.

Since quantities and prices are known for the base year, the distribution and scaling parameters can be derived unambiguously if the elasticities of substitution and transformation are given. Consequently, the problem of finding the necessary parameters reduces to the definition of the elasticities of substitution and transformation. In the WATSIM modelling system, uniform elasticities of substitution and of transformation are used due to lack of specific data on these parameters. WATSIM uses a value of +3.0 for the elasticity of substitution on all markets, and assumes a higher elasticity of transformation with -5.0.

As this choice of elasticity values may have an influence on the model outcomes, a sensitivity analysis is carried out. Hence, we use the existing reference run and perform some ceteris-paribus runs, only changing the (still uniform) elasticities of substitution and transformation, according to the following Table 5.5.

**Table 5.5. Elasticities of substitution and transformation in the sensitivity analysis**

	Elasticity of substitution	Elasticity of transformation
Reference run (REFB)	+3.0	-5.0
Reduced-Substitution run (RSUB)	+2.0	-4.0
Increased-Substitution run (ISUB)	+4.0	-6.0

Even though the change in the elasticities in absolute terms is equal between the two sensitivity runs RSUB and ISUB, both runs are shown to evaluate the degree of symmetry in the sensitivity. To keep the discussion readable, we restrict ourselves here to the results for the European Union, and to some key commodities, wherever they appear to be of general relevance, but of course point out important findings for other markets where necessary.

As a general result of the analysis, as one would expect, the main variables influenced by the Armington parameters are trade quantities. Whereas on the supply side, only few of the results differ by more than 1% between the reference run and either of the two sensitivity runs (with only the production of "other meat" showing a reaction that large in the EU), there are large differences in gross trade figures, of up to 36% in gross imports (other meat to Mercosur) and 35% in gross exports (other oil cakes from China). Mainly, large (relative) differences can be found in markets with only little trade, as in the two examples given above. For the EU, large differences in gross trade can be found for cheese imports (up to 32%), beef exports (20%), wheat imports (13%) and skim milk products imports (12%). For the main trade flows (such as cereal exports<sup>93</sup>, oilseed and products trade and meat trade -other than the mentioned beef exports), the sensitivity with respect to changes in the Armington elasticities is moderate with less than or around 5% in either direction. With the exceptions of beef and other meat, and also rape seeds and butter&cream, changes in the EU net trade positions are moderate as well. Due to the fact, that the absolute net trade quantity in many cases is much smaller than either imports or exports, net trade figures can be expected to be more sensitive to parameter changes than gross trade at least in relative terms. In some markets, however, such as protein crops and oil cakes from sunflower and rape seeds, higher Armington elasticities result in larger exports and lower imports, thus reducing net imports by relatively much even in absolute terms.

As it is true for the supply side, demand is little affected by the choice of the parameters. Total demand shows no changes larger than 5.8% (rape seed cake in Russia), with most changes well below 1% and large changes mainly on small markets again. For the EU, only the demand for cakes of other oil seeds shows a moderate change with up to 1.5%.

Finally, most international prices show only marginal sensitivity to the parameter values. Exceptions are again the market for cakes of other oil seeds (up to 5%), cakes of sunflower seeds (2.5%) and milk (2.5%), while most of the remaining price changes are below 1% in either direction. Given the 8-year horizon of the simulations, the impact on annual price changes can be considered to be small.

With respect to the question of symmetry of the outcome sensitivity posed above, we state that the changes do not show much symmetry, with differences in the relative changes being unsystematic. For international prices, and ignoring the sign, most changes are larger in the Reduced-Substitution run than in the Increased-Substitution run, which would be expected since the relative change in the parameters is larger in the former than in the latter. Prices for sunflower seeds and rape oil, however, react less in the first sensitivity run than in the second. The same holds for quantities, where most changes in the first scenario are larger than in the second, but again some markets show the opposite direction.

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<sup>93</sup> Due to the limits on subsidised exports, exports of barley are not influenced at all.

In order to check the relevance of the two sets of elasticities (i.e., elasticities of substitution and elasticities of transformation), two additional runs are performed, with only the elasticities of substitution or the elasticities of transformation being increased. The main result with respect to international prices is that they are affected almost exclusively by changes in the elasticities of substitution, while changes due to a higher elasticities of transformation are all below 0.7% (cheese), and mostly below or around 0.2%. By construction, this is also true for gross imports, while of course exports are more affected by the changes in the elasticities of transformation. Exports, however, show a significant sensitivity to changes in the elasticities of substitution, too, with most changes showing different signs for the two latter model runs.



**Table 5.7. Results of the WATSIM reference run (thousand hectares or tonnes)**

E15-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	43,181	43,570	43,690	43,302	38,498	37,403	36,692	0.09%	0.03%	-1.05%	-0.36%	-0.38%
YIE1	2.52	2.88	3.06	3.32	5.37	5.78	6.08	1.35%	0.63%	4.80%	0.91%	1.04%
PROP	108,622	125,311	133,825	143,740	206,866	216,143	223,251	1.44%	0.66%	3.70%	0.55%	0.65%
HCPC	121.97	117.39	114.21	112.94	111.80	115.59	115.70	-0.38%	-0.27%	-0.18%	0.42%	0.02%
CONP	40,276	39,538	39,113	39,275	41,782	43,495	43,460	-0.18%	-0.11%	0.55%	0.50%	-0.02%
FEEP	78,519	87,171	95,191	102,596	107,993	112,071	112,930	1.05%	0.88%	1.06%	0.46%	0.15%
INDP	6,497	7,022	7,876	8,550	11,525	13,346	14,197	0.78%	1.15%	3.22%	1.85%	1.24%
DEMP	135,587	144,646	154,101	162,716	175,627	183,856	185,620	0.65%	0.64%	1.10%	0.57%	0.19%
PEXP	13,275	17,863	22,412	29,699	28,266	37,716	43,331	3.01%	2.29%	1.95%	3.67%	2.81%
PIMP	38,538	38,850	44,493	49,500	7,630	9,566	9,335	0.08%	1.37%	-13.67%	2.87%	-0.49%
E15-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	4,038	4,388	4,816	5,284	10,548	11,271	11,503	0.83%	0.94%	6.75%	0.83%	0.41%
YIE1	1.57	1.70	1.71	1.76	2.55	2.64	2.71	0.78%	0.07%	3.38%	0.42%	0.55%
PROP	6,347	7,455	8,241	9,291	26,903	29,728	31,182	1.62%	1.01%	10.36%	1.26%	0.96%
HCPC	1.81	1.96	2.04	2.13	3.64	3.57	3.69	0.82%	0.38%	4.93%	-0.24%	0.70%
CONP	597	661	699	740	1,360	1,341	1,389	1.02%	0.55%	5.71%	-0.18%	0.71%
FEEP	137	156	159	171	3,115	3,430	3,428	1.24%	0.19%	28.17%	1.21%	-0.01%
INDP	14,732	16,627	19,565	22,101	41,344	43,897	45,371	1.22%	1.64%	6.43%	0.75%	0.66%
DEMP	15,661	17,583	20,582	23,175	46,568	49,460	51,010	1.16%	1.59%	7.04%	0.76%	0.62%
PEXP	442	496	811	841	924	552	509	1.16%	5.02%	1.10%	-6.24%	-1.61%
PIMP	9,997	10,531	13,306	14,703	17,662	20,285	20,336	0.52%	2.37%	2.39%	1.75%	0.05%
E15-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	3,693	4,247	4,787	5,248	11,665	12,673	13,232	1.41%	1.20%	7.70%	1.04%	0.87%
HCPC	11.99	12.77	13.79	14.08	19.97	21.34	22.01	0.64%	0.77%	3.13%	0.83%	0.62%
CONP	3,958	4,302	4,724	4,897	7,464	8,027	8,267	0.84%	0.94%	3.89%	0.91%	0.59%
INDP	46	49	52	55	152	181	188	0.51%	0.69%	9.35%	2.21%	0.76%
DEMP	5,255	5,706	6,426	6,501	11,765	12,693	13,063	0.83%	1.20%	5.17%	0.95%	0.58%
PEXP	737	1,155	1,780	2,316	3,662	4,249	4,493	4.61%	4.41%	6.20%	1.88%	1.12%
PIMP	2,179	2,679	3,429	3,747	4,113	4,271	4,323	2.09%	2.50%	1.53%	0.47%	0.24%
E15-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	5,119	6,181	8,487	10,241	20,265	20,835	21,426	1.90%	3.22%	7.52%	0.35%	0.56%
FEEP	10,510	12,290	16,031	18,086	34,184	36,316	37,610	1.58%	2.69%	6.51%	0.76%	0.70%
DEMP	10,792	12,476	16,311	18,191	34,324	36,461	37,757	1.46%	2.72%	6.40%	0.76%	0.70%
PEXP	1,068	1,194	1,721	2,436	1,297	862	794	1.12%	3.72%	-2.33%	-4.98%	-1.63%
PIMP	6,782	7,438	9,558	10,380	15,095	16,488	17,126	0.93%	2.54%	3.88%	1.11%	0.76%
E15-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	17,251	19,343	21,538	23,620	33,682	35,356	36,246	1.15%	1.08%	3.80%	0.61%	0.50%
HCPC	55.94	60.63	66.06	69.35	83.32	88.25	90.42	0.81%	0.86%	1.95%	0.72%	0.49%
CONP	18,474	20,424	22,624	24,116	31,138	33,209	33,967	1.01%	1.03%	2.70%	0.81%	0.45%
DEMP	18,540	20,481	22,694	24,197	31,386	33,411	34,173	1.00%	1.03%	2.74%	0.78%	0.45%
PEXP	1,557	1,971	2,483	2,967	3,279	2,916	3,023	2.39%	2.34%	2.34%	-1.46%	0.72%
PIMP	2,842	3,126	3,600	3,651	869	970	950	0.96%	1.42%	-11.17%	1.38%	-0.42%
E15-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	2,445	2,742	3,101	3,514	6,454	6,818	6,844	1.15%	1.24%	6.30%	0.69%	0.08%
HCPC	7.54	8.31	9.00	9.81	16.16	16.96	17.10	0.98%	0.81%	5.00%	0.61%	0.16%
CONP	2,489	2,798	3,083	3,411	6,039	6,382	6,422	1.18%	0.97%	5.76%	0.69%	0.13%
DEMP	2,492	2,802	3,086	3,415	6,045	6,389	6,428	1.18%	0.97%	5.76%	0.69%	0.12%
PEXP	376	443	551	722	471	545	531	1.65%	2.19%	-1.29%	1.84%	-0.52%
PIMP	457	484	560	634	77	116	115	0.57%	1.49%	-15.25%	5.26%	-0.17%

CEE-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	25,319	24,966	24,385	24,257	24,631	23,631	23,166	-0.14%	-0.23%	0.08%	-0.52%	-0.40%
YIE1	1.96	2.24	2.53	2.85	3.38	3.33	3.54	1.36%	1.23%	2.44%	-0.19%	1.24%
PROP	49,582	55,966	61,755	69,170	83,341	78,729	82,088	1.22%	0.99%	2.53%	-0.71%	0.84%
HCPC	202.42	196.32	186.64	180.31	161.29	159.45	157.88	-0.31%	-0.50%	-1.21%	-0.14%	-0.20%
CONP	18,111	17,959	17,456	17,260	16,626	16,527	16,297	-0.08%	-0.28%	-0.41%	-0.07%	-0.28%
FEEP	26,870	32,815	40,070	48,966	46,959	46,937	47,910	2.02%	2.02%	1.33%	-0.01%	0.41%
INDP	1,057	1,156	1,438	1,674	2,445	2,558	2,665	0.90%	2.21%	4.52%	0.57%	0.82%
DEMP	52,853	59,055	66,446	75,865	76,548	76,263	77,074	1.12%	1.19%	1.19%	-0.05%	0.21%
PEXP	2,149	3,222	2,524	3,680	4,032	5,630	7,695	4.13%	-2.41%	3.98%	4.26%	6.45%
PIMP	7,471	6,635	8,416	9,683	3,335	3,165	2,680	-1.18%	2.41%	-7.42%	-0.65%	-3.27%
CEE-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	1,667	1,793	1,970	1,963	2,707	3,236	3,277	0.73%	0.95%	2.68%	2.26%	0.25%
YIE1	1.09	1.22	1.28	1.33	1.40	1.51	1.59	1.15%	0.41%	0.78%	0.93%	1.10%
PROP	1,823	2,196	2,514	2,609	3,793	4,881	5,220	1.88%	1.36%	3.49%	3.20%	1.35%
HCPC	0.65	0.37	0.41	0.49	1.30	1.66	1.90	-5.48%	1.09%	10.06%	3.04%	2.81%
CONP	58	34	39	47	134	171	196	-5.29%	1.34%	10.93%	3.09%	2.77%
FEEP	31	31	42	35	162	137	132	0.14%	-3.04%	11.91%	-2.07%	-0.74%
INDP	1,737	2,093	2,396	2,636	3,787	4,346	4,509	1.88%	1.36%	3.89%	1.74%	0.74%
DEMP	1,938	2,284	2,613	2,861	4,368	4,972	5,166	1.66%	1.35%	4.37%	1.63%	0.77%
PEXP	245	334	251	148	555	480	629	3.16%	-2.81%	6.83%	-1.80%	5.56%
PIMP	392	419	398	450	499	572	575	0.65%	-0.51%	1.91%	1.72%	0.10%
CEE-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	652	813	907	998	1,509	1,728	1,790	2.24%	-1.09%	4.34%	1.71%	0.71%
HCPC	6.47	6.82	7.42	7.98	11.37	13.16	14.01	0.52%	0.86%	3.62%	1.84%	1.26%
CONP	579	624	694	764	1,172	1,364	1,447	0.75%	1.08%	4.46%	1.91%	1.19%
INDP	1	1	2	1	51	33	39	3.82%	7.64%	32.58%	-5.01%	2.86%
DEMP	751	810	919	1,021	1,616	1,832	1,951	0.75%	1.28%	4.82%	1.58%	1.27%
PEXP	111	279	244	267	521	587	591	9.69%	-1.33%	6.53%	1.50%	0.14%
PIMP	240	265	268	298	615	691	751	0.97%	0.13%	7.17%	1.47%	1.68%
CEE-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	887	1,042	1,235	1,388	2,038	2,329	2,414	1.63%	1.71%	4.26%	1.68%	0.72%
FEEP	1,504	1,927	2,685	3,764	3,493	3,742	3,804	2.51%	3.37%	2.22%	0.86%	0.33%
DEMP	1,504	1,927	2,685	3,764	3,493	3,742	3,804	2.51%	3.37%	2.22%	0.86%	0.33%
PEXP	34	19	41	35	597	769	819	-5.53%	7.61%	25.13%	3.22%	1.27%
PIMP	652	904	1,501	2,437	2,048	2,180	2,210	3.33%	5.20%	2.63%	0.78%	0.27%
CEE-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	4,974	5,648	6,263	7,643	7,027	6,784	6,796	1.28%	1.04%	0.96%	-0.44%	0.04%
HCPC	49.30	53.39	58.63	68.06	63.05	63.69	63.58	0.80%	0.94%	0.61%	0.13%	-0.03%
CONP	4,412	4,885	5,485	6,517	6,499	6,601	6,563	1.02%	1.17%	1.42%	0.19%	-0.12%
DEMP	4,596	5,114	5,722	6,789	6,580	6,692	6,655	1.07%	1.13%	1.17%	0.21%	-0.11%
PEXP	606	770	801	958	750	503	529	2.42%	0.40%	-0.55%	-4.87%	1.01%
PIMP	216	239	267	126	230	411	389	1.03%	1.09%	-1.25%	7.56%	-1.09%
CEE-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	503	571	663	792	883	1,031	1,099	1.26%	1.52%	2.41%	1.96%	1.29%
HCPC	5.18	5.72	6.53	7.66	7.80	8.98	9.59	1.01%	1.32%	1.50%	1.78%	1.32%
CONP	463	524	611	734	804	931	990	1.23%	1.55%	2.32%	1.85%	1.24%
DEMP	469	530	620	744	806	933	992	1.24%	1.57%	2.22%	1.85%	1.23%
PEXP	32	50	50	48	107	137	147	4.63%	-0.00%	6.51%	3.14%	1.42%
PIMP	2	5	4	2	35	38	40	10.92%	-1.62%	19.23%	1.03%	1.03%

<b>RUS-Cereals</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
LEV1	68,397	66,004	64,475	68,924	52,393	53,795	53,464	-0.36%	-0.23%	-1.71%	0.33%	-0.12%
YIE1	0.96	1.09	1.26	1.22	1.65	1.45	1.51	1.35%	1.38%	2.33%	-1.62%	0.84%
PROP	65,474	72,229	80,932	83,755	86,694	78,141	80,976	0.99%	1.14%	0.57%	-1.29%	0.72%
HCPC	249.51	237.37	248.16	234.17	156.02	165.31	170.42	-0.50%	0.45%	-3.79%	0.73%	0.61%
CONP	31,608	30,643	32,535	31,254	23,037	23,742	24,037	-0.31%	0.60%	-2.84%	0.38%	0.25%
FEEP	#NV	#NV	#NV	#NV	43,742	43,654	46,327	#NV	#NV	#NV	-0.03%	1.20%
INDP	#NV	#NV	#NV	#NV	1,994	2,575	2,691	#NV	#NV	#NV	3.25%	0.89%
DEMP	77,180	88,465	101,706	104,920	85,216	86,980	90,083	1.37%	1.40%	-1.46%	0.26%	0.70%
PEXP	7,208	826	279	7,176	805	322	337	-19.48%	-10.28%	9.23%	-10.82%	0.91%
PIMP	23,930	18,642	21,029	27,343	5,564	9,162	9,441	-2.47%	1.21%	-10.49%	6.43%	0.60%
<b>RUS-Oilseeds</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
LEV1	4,577	4,445	4,264	4,167	4,394	4,391	4,344	-0.29%	-0.41%	0.25%	-0.01%	-0.21%
YIE1	0.77	0.88	0.80	0.92	0.75	0.83	0.85	1.35%	-1.02%	-0.49%	1.30%	0.38%
PROP	3,534	3,925	3,400	3,824	3,304	3,662	3,692	1.06%	-1.43%	-0.24%	1.29%	0.16%
HCPC	2.22	2.41	2.29	2.43	0.28	0.62	0.60	0.85%	-0.53%	-16.07%	10.53%	-0.79%
CONP	281	311	300	324	41	89	85	1.04%	-0.37%	-15.29%	10.19%	-0.92%
FEEP	170	172	155	154	433	524	663	0.10%	-1.02%	8.93%	2.41%	4.82%
INDP	3,088	3,566	3,235	3,445	1,811	1,690	1,647	1.45%	-0.97%	-4.72%	-0.86%	-0.51%
DEMP	4,778	5,300	4,890	5,109	2,640	2,655	2,744	1.04%	-0.80%	-5.01%	0.07%	0.66%
PEXP	30	27	25	322	1,049	1,385	1,363	-1.10%	-0.78%	36.61%	3.53%	-0.32%
PIMP	1,280	1,399	1,517	2,077	222	379	414	0.89%	0.82%	-14.80%	6.91%	1.78%
<b>RUS-Oils</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
PROP	1,233	1,490	1,354	1,452	787	726	701	1.91%	-0.95%	-4.42%	-1.00%	-0.70%
HCPC	6.76	7.16	7.15	7.72	7.72	6.94	7.06	0.58%	-0.01%	0.64%	-1.32%	0.33%
CONP	856	925	938	1,030	1,140	997	996	0.77%	0.14%	1.64%	-1.66%	-0.02%
INDP	#NV	#NV	#NV	#NV	0	79	88	#NV	#NV	#NV	#DIV/O!	2.18%
DEMP	1,152	1,265	1,244	1,198	1,617	1,511	1,537	0.94%	-0.16%	2.21%	-0.84%	0.34%
PEXP	283	227	196	692	28	24	21	-2.17%	-1.45%	-15.01%	-1.86%	-2.64%
PIMP	108	48	65	98	856	807	855	-7.75%	3.04%	23.96%	-0.73%	1.16%
<b>RUS-Cakes</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
PROP	1,299	1,544	1,434	1,502	940	883	866	1.74%	-0.74%	-3.46%	-0.78%	-0.39%
FEEP	5,682	5,949	7,693	6,567	977	1,067	1,228	0.46%	2.60%	-15.80%	1.11%	2.85%
DEMP	5,682	5,949	7,693	6,567	977	1,067	1,228	0.46%	2.60%	-15.80%	1.11%	2.85%
PEXP	111	203	8	1	5	1	1	6.22%	-27.37%	-4.12%	-22.91%	17.82%
PIMP	4,494	4,608	6,268	5,067	41	184	364	0.25%	3.12%	-34.24%	20.64%	14.62%
<b>RUS-Meat</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
PROP	4,616	5,591	6,305	6,958	4,736	4,580	4,895	1.93%	1.21%	-2.36%	-0.42%	1.34%
HCPC	40.56	47.38	52.11	59.46	51.89	50.03	51.29	1.57%	0.96%	-0.04%	-0.46%	0.50%
CONP	5,142	6,117	6,833	7,935	7,664	7,186	7,234	1.75%	1.11%	0.96%	-0.80%	0.13%
DEMP	5,177	6,162	6,883	7,992	7,691	7,211	7,260	1.76%	1.11%	0.93%	-0.80%	0.14%
PEXP	0	62	194	219	41	66	96	0.00%	12.13%	-12.21%	6.26%	7.78%
PIMP	561	624	772	1,167	2,995	2,698	2,463	1.07%	2.15%	11.96%	-1.30%	-1.81%
<b>RUS-CHES</b>	<b>1964 / 86</b>	<b>1974 / 76</b>	<b>1984 / 86</b>	<b>1994 / 96</b>	<b>1997</b>	<b>2005</b>	<b>2010</b>	<b>ggr. 1975</b>	<b>ggr. 1985</b>	<b>ggr. 1995</b>	<b>ggr. 2005</b>	<b>ggr. 2010</b>
PROP	156	205	237	288	378	336	360	2.77%	1.46%	3.96%	-1.46%	1.39%
HCPC	1.27	1.64	1.85	2.21	3.46	2.68	2.90	2.63%	1.23%	5.34%	-3.14%	1.59%
CONP	160	212	243	295	511	385	410	2.82%	1.39%	6.38%	-3.48%	1.27%
DEMP	160	212	243	295	511	385	410	2.82%	1.39%	6.38%	-3.48%	1.27%
PEXP	0	0	0	0	2	15	17	0.00%	0.00%	0.00%	28.64%	2.53%
PIMP	4	7	6	6	136	64	66	4.73%	-0.96%	29.55%	-8.99%	0.62%

CHN- Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	92,840	91,804	96,009	97,578	92,779	91,177	88,811	-0.11%	0.45%	-0.28%	-0.22%	-0.52%
YIE1	1.44	1.59	1.75	1.96	4.08	4.65	4.98	1.00%	0.97%	7.31%	1.66%	1.39%
PROP	133,502	145,793	167,897	191,432	378,270	424,072	442,611	0.88%	1.42%	7.00%	1.44%	0.86%
HCPC	148.76	147.06	155.63	160.38	192.66	182.37	173.70	-0.12%	0.57%	1.79%	-0.68%	-0.97%
CONP	109,170	116,501	133,109	146,656	240,959	242,193	238,216	0.65%	1.34%	5.07%	0.06%	-0.33%
FEEP	12,119	16,687	20,307	28,827	111,737	145,024	170,796	3.25%	1.98%	15.27%	3.31%	3.33%
INDP	#NV	#NV	#NV	#NV	12,587	13,728	14,885	#NV	#NV	#NV	1.09%	1.63%
DEMP	138,285	150,971	173,038	196,758	395,796	433,966	457,817	0.88%	1.37%	7.14%	1.16%	1.08%
PEXP	1,773	1,840	1,778	2,566	3,069	3,941	4,394	0.37%	-0.34%	4.65%	3.18%	2.20%
PIMP	7,571	5,955	7,035	8,634	6,371	13,834	19,600	-2.37%	1.68%	-0.82%	10.18%	7.22%
CHN- Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	18,916	17,944	17,394	17,331	25,713	27,111	27,515	-0.53%	-0.31%	3.31%	0.66%	0.30%
YIE1	0.84	0.96	1.00	1.06	1.78	1.88	2.00	1.31%	0.42%	4.89%	0.74%	1.20%
PROP	15,949	17,229	17,422	18,328	45,698	51,098	55,038	0.77%	0.11%	8.37%	1.41%	1.50%
HCPC	6.08	6.18	5.94	5.58	6.23	6.70	7.09	0.16%	-0.41%	0.40%	0.91%	1.14%
CONP	4,466	4,894	5,072	5,099	7,800	8,895	9,734	0.92%	0.36%	3.65%	1.66%	1.82%
FEEP	#NV	#NV	#NV	#NV	4,939	6,493	7,208	#NV	#NV	#NV	3.48%	2.11%
INDP	7,162	8,096	8,466	9,280	34,450	43,388	47,769	1.23%	0.45%	12.41%	2.93%	1.94%
DEMP	15,483	17,088	17,584	18,768	51,155	63,391	69,619	0.99%	0.29%	9.31%	2.72%	1.89%
PEXP	661	681	492	405	444	232	173	0.31%	-3.20%	-0.85%	-7.80%	-5.70%
PIMP	252	503	687	1,027	5,811	12,526	14,753	7.16%	3.16%	19.48%	10.08%	3.33%
CHN-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,661	1,857	2,000	2,208	8,821	11,003	12,100	1.12%	0.75%	13.16%	2.80%	1.92%
HCPC	1.68	1.70	1.75	1.81	6.50	7.94	8.63	0.13%	0.29%	11.54%	2.52%	1.70%
CONP	1,234	1,350	1,500	1,656	8,140	10,540	11,825	0.90%	1.06%	15.14%	3.28%	2.33%
INDP	#NV	#NV	#NV	#NV	1	1	1	#NV	#NV	#NV	0.20%	0.80%
DEMP	1,649	1,836	2,037	2,260	11,623	15,141	16,983	1.08%	1.04%	15.62%	3.36%	2.32%
PEXP	95	95	69	79	611	873	949	-0.03%	-3.15%	19.94%	4.56%	1.68%
PIMP	73	73	105	150	3,558	5,011	5,831	0.08%	3.70%	34.08%	4.37%	3.08%
CHN- Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	4,046	4,581	4,873	5,360	21,891	27,942	30,849	1.25%	0.62%	13.34%	3.10%	2.00%
FEEP	2,835	3,238	3,535	3,814	22,229	31,078	35,712	1.34%	0.88%	16.56%	4.28%	2.82%
DEMP	4,028	4,555	4,860	5,361	25,170	35,049	40,145	1.24%	0.65%	14.69%	4.23%	2.75%
PEXP	30	45	35	37	379	73	62	4.07%	-2.58%	22.04%	-18.60%	-3.22%
PIMP	12	18	25	36	3,660	7,180	9,358	3.92%	3.02%	51.77%	8.79%	5.44%
CHN- Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	6,633	7,597	8,507	9,666	52,949	69,682	81,005	1.37%	1.14%	16.46%	3.49%	3.06%
HCPC	8.85	9.49	9.79	10.46	42.35	52.02	59.02	0.70%	0.31%	12.98%	2.60%	2.56%
CONP	6,498	7,515	8,387	9,566	52,970	69,078	80,927	1.47%	1.10%	16.60%	3.37%	3.22%
DEMP	6,507	7,526	8,399	9,580	53,024	69,156	81,021	1.47%	1.10%	16.60%	3.38%	3.22%
PEXP	168	131	184	185	795	1,962	1,914	-2.45%	3.46%	12.94%	11.96%	-0.49%
PIMP	40	61	76	100	870	1,436	1,931	4.18%	2.27%	22.54%	6.46%	6.10%
CHN- CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	59	53	54	61	191	223	238	-1.06%	0.33%	11.02%	1.96%	1.31%
HCPC	0.08	0.07	0.06	0.07	0.16	0.19	0.20	-1.75%	-0.40%	7.96%	2.07%	0.89%
CONP	59	53	55	62	203	254	274	-1.04%	0.35%	11.48%	2.84%	1.53%
DEMP	59	53	55	62	203	254	274	-1.04%	0.35%	11.47%	2.84%	1.53%
PEXP	0	0	0	0	2	1	1	4.42%	-0.84%	45.26%	-10.50%	-1.81%
PIMP	0	1	1	1	14	31	36	2.18%	2.26%	28.78%	10.45%	3.04%

JAP-Cereals	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	4,305	4,012	3,158	2,912	2,197	2,020	1,910	-0.70%	-2.36%	-2.98%	-1.05%	-1.11%
YIE1	3.14	3.60	3.56	3.91	4.17	4.36	4.50	1.38%	-0.13%	1.33%	0.56%	0.67%
PROP	13,529	14,455	11,229	11,387	9,153	8,798	8,603	0.66%	-2.49%	-1.69%	-0.49%	-0.45%
HCPC	152.31	147.51	142.79	142.39	132.46	130.60	128.99	-0.32%	-0.32%	-0.62%	-0.18%	-0.25%
CONP	15,058	15,040	15,097	15,679	16,695	16,611	16,389	-0.01%	0.04%	0.84%	-0.06%	-0.27%
FEEP	6,032	8,257	11,155	12,444	16,999	15,465	14,267	3.19%	3.05%	3.57%	-1.18%	-1.60%
INDP	#NV	#NV	#NV	#NV	2,921	3,139	3,102	#NV	#NV	#NV	0.90%	-0.24%
DEMP	22,864	25,206	28,162	30,274	37,245	35,819	34,344	0.98%	1.12%	2.36%	-0.49%	-0.84%
PEXP	91	200	558	299	405	352	328	8.13%	10.82%	-2.64%	-1.73%	-1.41%
PIMP	10,193	12,803	15,939	19,537	28,954	27,373	26,070	2.31%	2.22%	5.10%	-0.70%	-0.97%
JAP-Oilseeds	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	#NV	#NV	#NV	#NV	98	116	112	#NV	#NV	#NV	2.18%	-0.70%
YIE1	#NV	#NV	#NV	#NV	2.01	1.98	2.02	#NV	#NV	#NV	-0.16%	0.35%
PROP	#NV	#NV	#NV	#NV	196	230	226	#NV	#NV	#NV	2.02%	-0.35%
HCPC	8.13	8.90	9.09	8.87	9.70	10.35	10.68	0.91%	0.21%	0.55%	0.80%	0.63%
CONP	804	907	961	977	1,222	1,315	1,356	1.22%	0.57%	2.02%	0.92%	0.62%
FEEP	#NV	#NV	#NV	#NV	254	208	186	#NV	#NV	#NV	-2.47%	-2.21%
INDP	2,578	3,230	4,100	4,175	6,274	6,413	6,497	2.28%	2.41%	3.61%	0.27%	0.26%
DEMP	3,464	4,221	5,135	5,228	7,899	8,089	8,193	2.00%	1.98%	3.65%	0.30%	0.26%
PEXP	3	0	0	1	3	1	1	-22.42%	3.69%	20.43%	-12.15%	-2.60%
PIMP	3,089	3,849	4,950	4,961	7,885	7,859	7,967	2.22%	2.55%	3.96%	-0.04%	0.27%
JAP-Oils	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	701	867	1,060	1,094	1,857	1,888	1,909	2.14%	2.04%	4.78%	0.21%	0.22%
HCPC	4.89	5.98	6.79	8.32	12.90	12.98	13.26	2.04%	1.27%	5.49%	0.08%	0.43%
CONP	484	610	718	916	1,625	1,653	1,686	2.35%	1.64%	7.05%	0.21%	0.40%
INDP	#NV	#NV	#NV	#NV	0	0	0	#NV	#NV	#NV	#DIV/0!	#DIV/0!
DEMP	724	903	1,096	1,278	2,548	2,599	2,662	2.24%	1.96%	7.28%	0.25%	0.48%
PEXP	24	26	52	41	25	49	60	0.85%	7.36%	-6.15%	9.05%	4.13%
PIMP	46	63	92	217	717	759	810	3.20%	3.83%	18.66%	0.71%	1.31%
JAP-Cakes	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,832	2,291	2,973	3,105	4,533	4,609	4,638	2.26%	2.64%	3.58%	0.21%	0.13%
FEEP	1,964	2,442	3,284	3,413	5,525	5,087	4,886	2.20%	3.01%	4.43%	-1.03%	-0.80%
DEMP	1,964	2,442	3,284	3,413	5,525	5,087	4,886	2.20%	3.01%	4.43%	-1.03%	-0.80%
PEXP	#NV	#NV	#NV	#NV	3	42	93	#NV	#NV	#NV	41.88%	17.25%
PIMP	136	162	311	339	994	520	341	1.79%	6.73%	10.16%	-7.77%	-8.10%
JAP-Meat	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	849	1,125	1,670	2,059	3,094	3,037	2,916	2.85%	4.02%	5.28%	-0.23%	-0.81%
HCPC	9.18	12.45	17.72	21.29	41.96	47.25	50.26	3.10%	3.59%	7.45%	1.49%	1.24%
CONP	908	1,271	1,876	2,345	5,290	6,010	6,385	3.41%	3.97%	9.02%	1.61%	1.22%
DEMP	927	1,296	1,915	2,393	5,397	6,133	6,515	3.41%	3.98%	9.02%	1.61%	1.22%
PEXP	1	1	2	5	6	9	7	-8.96%	11.68%	11.82%	5.34%	-4.90%
PIMP	91	163	245	353	2,302	3,102	3,604	6.05%	4.18%	20.50%	3.80%	3.05%
JAP-CHES	1964 / 86	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	18	34	42	50	114	125	138	6.35%	2.22%	8.58%	1.16%	2.00%
HCPC	0.31	0.59	0.73	0.86	2.26	2.38	2.60	6.63%	2.12%	9.89%	0.65%	1.78%
CONP	31	60	77	94	284	303	330	6.95%	2.49%	11.48%	0.81%	1.72%
DEMP	31	60	77	94	284	303	330	6.95%	2.49%	11.48%	0.81%	1.72%
PEXP	0	0	0	0	0	0	1	7.18%	13.49%	3.66%	36.27%	2.63%
PIMP	12	26	35	45	170	178	193	7.79%	2.83%	14.17%	0.58%	1.63%

ANZ-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	10,525	13,116	11,493	12,601	16,070	16,880	17,776	2.23%	-1.31%	2.83%	0.62%	1.04%
YIE1	1.28	1.14	1.17	1.40	1.97	2.14	2.29	-1.16%	0.29%	4.39%	1.04%	1.37%
PROP	13,491	14,962	13,495	17,632	31,614	36,086	40,684	1.04%	-1.03%	7.35%	1.67%	2.43%
HCPC	103.93	104.14	98.76	90.57	88.11	84.37	82.79	0.02%	-0.53%	-0.95%	-0.54%	-0.38%
CONP	1,457	1,540	1,550	1,513	1,947	2,010	2,074	0.55%	0.06%	1.92%	0.40%	0.63%
FEEP	#NV	#NV	#NV	#NV	5,878	6,553	6,839	#NV	#NV	#NV	1.37%	0.86%
INDP	347	376	421	491	530	837	892	0.83%	1.13%	1.93%	5.87%	1.28%
DEMP	4,825	5,657	6,185	5,863	10,379	11,598	12,082	1.60%	0.90%	4.41%	1.40%	0.82%
PEXP	7,523	7,377	11,014	8,960	24,660	24,861	28,977	-0.20%	4.09%	6.95%	0.10%	3.11%
PIMP	183	78	81	108	185	374	377	-8.21%	0.36%	7.16%	9.20%	0.16%
ANZ-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	104	131	339	381	1,312	1,458	1,597	2.33%	9.94%	11.94%	1.33%	1.84%
YIE1	0.83	0.96	0.76	0.81	1.52	1.74	1.85	1.45%	-2.36%	5.98%	1.70%	1.21%
PROP	87	127	257	309	2,000	2,543	2,958	3.82%	7.35%	18.63%	3.05%	3.07%
HCPC	3.78	4.25	3.99	3.86	4.91	5.44	5.69	1.18%	-0.63%	1.75%	1.28%	0.92%
CONP	53	63	63	65	109	129	142	1.71%	-0.05%	4.72%	2.15%	1.94%
FEEP	#NV	#NV	#NV	#NV	569	659	696	#NV	#NV	#NV	1.85%	1.10%
INDP	218	246	313	334	943	1,050	1,128	1.21%	2.42%	9.64%	1.35%	1.44%
DEMP	278	324	390	426	1,648	1,872	2,003	1.55%	1.88%	12.75%	1.61%	1.36%
PEXP	1	13	103	51	705	1,073	1,362	27.15%	22.55%	17.42%	5.39%	4.89%
PIMP	199	210	187	170	352	404	407	0.56%	-1.19%	5.44%	1.74%	0.14%
ANZ-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	49	55	87	103	246	274	295	1.07%	4.78%	9.04%	1.36%	1.49%
HCPC	4.09	4.21	5.20	7.44	17.41	17.01	18.23	0.28%	2.13%	10.60%	-0.29%	1.40%
CONP	57	62	82	125	386	405	457	0.81%	2.75%	13.82%	0.60%	2.45%
INDP	#NV	#NV	#NV	#NV	3	4	4	#NV	#NV	#NV	3.66%	0.00%
DEMP	90	102	134	168	501	528	599	1.30%	2.74%	11.64%	0.66%	2.56%
PEXP	4	3	6	11	58	76	85	-1.75%	7.03%	20.97%	3.47%	2.26%
PIMP	45	50	56	76	325	332	390	1.17%	1.00%	15.84%	0.27%	3.27%
ANZ-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	54	69	101	141	502	560	601	2.36%	4.00%	14.26%	1.38%	1.42%
FEEP	67	91	128	156	643	816	911	3.05%	3.46%	14.39%	3.02%	2.23%
DEMP	67	91	128	156	643	816	911	3.05%	3.46%	14.39%	3.02%	2.23%
PEXP	1	2	2	1	38	15	10	5.32%	-2.86%	30.05%	-11.01%	-7.79%
PIMP	#NV	#NV	#NV	#NV	180	269	319	#NV	#NV	#NV	5.15%	3.47%
ANZ-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	2,596	2,730	3,270	3,425	4,571	4,938	5,079	0.51%	1.82%	2.83%	0.97%	0.56%
HCPC	107.71	105.55	111.89	109.18	101.45	106.93	107.44	-0.20%	0.59%	-0.81%	0.66%	0.10%
CONP	1,509	1,562	1,757	1,824	2,242	2,546	2,690	0.34%	1.18%	2.05%	1.60%	1.11%
DEMP	1,573	1,642	1,883	1,891	2,338	2,655	2,801	0.43%	1.38%	1.82%	1.60%	1.08%
PEXP	1,026	1,063	1,391	1,527	2,261	2,345	2,349	0.36%	2.73%	4.13%	0.46%	0.03%
PIMP	2	1	2	4	32	64	71	-1.98%	1.21%	28.09%	9.24%	2.10%
ANZ-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	163	179	182	189	552	672	742	0.93%	0.21%	9.67%	2.49%	2.00%
HCPC	3.22	3.87	3.64	5.37	9.95	10.70	11.32	1.86%	-0.59%	8.73%	0.91%	1.13%
CONP	45	57	57	90	220	255	283	2.41%	0.00%	11.87%	1.86%	2.11%
DEMP	45	57	57	90	220	255	283	2.41%	0.00%	11.87%	1.86%	2.11%
PEXP	121	126	128	110	386	472	520	0.40%	0.16%	9.63%	2.55%	1.96%
PIMP	4	5	6	8	33	55	61	3.10%	2.82%	14.81%	6.59%	2.09%

MER-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVEL	27,139	29,622	31,347	32,113	32,753	33,976	34,353	0.88%	0.57%	0.37%	0.46%	0.22%
YIE1	1.34	1.33	1.41	1.55	2.65	2.80	3.03	-0.10%	0.59%	5.40%	0.67%	1.64%
PROP	36,438	39,381	44,185	49,755	86,770	94,976	104,181	0.78%	-1.16%	5.79%	1.14%	1.87%
HCPC	108.43	108.89	105.69	110.58	111.29	115.94	117.87	0.04%	-0.30%	0.43%	0.51%	0.33%
CONP	13,412	14,459	14,997	16,753	25,609	29,419	31,698	0.75%	0.37%	4.56%	1.75%	1.50%
FEEP	12,172	14,463	16,674	18,801	37,320	42,649	48,197	1.74%	1.43%	6.94%	1.68%	2.48%
INDP	#NV	#NV	#NV	#NV	2,028	2,084	2,310	#NV	#NV	#NV	0.34%	2.08%
DEMP	30,185	34,053	37,032	41,379	74,035	84,366	93,320	1.21%	0.84%	5.94%	1.65%	2.04%
PEXP	10,717	8,480	9,853	10,821	17,173	15,759	16,582	-2.31%	1.51%	4.74%	-1.07%	1.02%
PIMP	3,168	3,677	2,897	4,328	2,401	5,149	5,720	1.50%	-2.36%	-1.55%	10.01%	2.13%
MER-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVEL	7,347	9,021	10,692	13,297	25,506	26,847	27,732	2.07%	1.71%	7.51%	0.64%	0.65%
YIE1	0.77	0.71	0.78	1.01	1.98	2.19	2.30	-0.79%	0.99%	8.05%	1.30%	0.96%
PROP	5,625	6,378	8,339	13,455	50,380	58,788	63,711	1.27%	2.72%	16.17%	1.95%	1.62%
HCPC	4.76	5.32	4.63	3.30	3.75	3.78	3.94	1.11%	-1.36%	-1.75%	0.08%	0.87%
CONP	590	705	658	500	863	958	1,061	1.80%	-0.69%	2.29%	1.31%	2.06%
FEEP	#NV	#NV	#NV	#NV	1,143	1,158	1,224	#NV	#NV	#NV	0.16%	1.11%
INDP	4,142	4,600	6,109	8,679	38,734	49,236	53,499	1.05%	2.88%	16.64%	3.04%	1.67%
DEMP	5,378	6,114	7,618	10,171	42,556	53,323	57,841	1.29%	2.22%	15.41%	2.86%	1.64%
PEXP	104	271	614	2,789	9,957	8,731	9,386	10.07%	8.51%	26.13%	-1.63%	1.46%
PIMP	10	19	40	48	1,316	3,266	3,515	6.85%	7.61%	33.82%	12.03%	1.48%
MER-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,257	1,340	1,648	2,022	8,696	10,913	11,870	0.64%	2.09%	14.87%	2.88%	1.70%
HCPC	5.68	6.42	6.85	8.46	13.24	16.19	18.20	1.23%	0.65%	5.64%	2.55%	2.37%
CONP	704	853	973	1,283	3,047	4,109	4,894	1.94%	1.33%	9.98%	3.81%	3.56%
INDP	#NV	#NV	#NV	#NV	4	10	12	#NV	#NV	#NV	12.14%	3.71%
DEMP	809	963	1,097	1,492	4,427	5,980	7,102	1.76%	1.32%	12.33%	3.83%	3.50%
PEXP	477	512	584	607	4,962	5,768	5,814	0.72%	1.32%	19.52%	1.90%	0.16%
PIMP	62	84	82	115	266	837	1,047	3.07%	-0.25%	10.33%	15.40%	4.58%
MER-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	2,013	2,175	3,222	4,975	27,779	35,574	38,638	0.78%	4.01%	19.66%	3.14%	1.67%
FEEP	661	761	968	1,736	7,659	9,281	10,847	1.42%	2.44%	18.81%	2.43%	3.17%
DEMP	670	793	976	1,739	7,659	9,281	10,847	1.70%	2.10%	18.73%	2.43%	3.17%
PEXP	1,338	1,384	2,226	3,252	20,977	27,138	28,845	0.33%	4.87%	20.55%	3.27%	1.23%
PIMP	#NV	#NV	#NV	#NV	36	845	1,053	#NV	#NV	#NV	48.20%	4.50%
MER-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	5,815	6,893	7,035	7,353	16,669	19,186	21,312	1.72%	0.20%	7.45%	1.77%	2.12%
HCPC	40.47	44.72	42.75	44.34	65.51	70.59	74.99	1.00%	-0.45%	3.62%	0.94%	1.22%
CONP	5,011	5,941	6,065	6,723	15,075	17,914	20,164	1.72%	0.21%	7.88%	2.18%	2.39%
DEMP	5,025	5,993	6,112	6,755	15,423	18,009	20,272	1.78%	0.20%	8.02%	1.96%	2.40%
PEXP	802	914	955	658	1,280	1,335	1,243	1.32%	0.44%	2.47%	0.53%	-1.42%
PIMP	11	14	33	60	19	160	203	2.17%	8.75%	-4.38%	30.42%	4.88%
MER-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	232	253	271	298	561	634	732	0.85%	0.69%	6.26%	1.54%	2.92%
HCPC	1.83	1.87	1.88	1.93	2.48	2.56	2.79	0.21%	0.03%	2.34%	0.40%	1.74%
CONP	227	249	267	292	571	649	750	0.92%	0.71%	6.54%	1.61%	2.94%
DEMP	227	249	267	292	571	649	750	0.92%	0.71%	6.54%	1.61%	2.94%
PEXP	6	5	5	7	34	37	42	-0.89%	-0.18%	17.04%	1.06%	2.57%
PIMP	0	1	1	1	44	51	60	13.60%	1.04%	35.11%	1.86%	3.30%

USA-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	60,833	62,716	60,460	68,271	64,659	64,032	64,248	0.31%	-0.37%	0.56%	-0.12%	0.07%
YIE1	2.88	3.25	3.58	3.35	5.17	5.73	6.06	1.22%	0.96%	3.12%	1.28%	1.13%
PROP	175,316	204,068	216,422	229,045	334,561	366,920	389,372	1.53%	0.59%	3.70%	1.16%	1.19%
HCPC	84.15	82.81	79.68	81.86	115.90	119.03	121.49	-0.16%	-0.38%	3.17%	0.33%	0.41%
CONP	16,806	17,073	16,900	17,860	31,497	34,262	36,310	0.16%	-0.10%	5.33%	1.06%	1.17%
FEEP	#NV	#NV	#NV	#NV	167,300	174,646	177,383	#NV	#NV	#NV	0.54%	0.31%
INDP	6,586	7,154	8,275	10,107	40,394	47,472	52,441	0.83%	1.47%	14.12%	2.04%	2.01%
DEMP	145,087	158,390	173,583	157,633	248,671	266,358	276,411	0.88%	0.92%	3.04%	0.86%	0.74%
PEXP	45,332	37,779	43,341	74,346	78,969	107,786	120,207	-1.81%	1.38%	5.13%	3.97%	2.21%
PIMP	436	372	532	523	7,268	7,220	7,246	-1.57%	3.63%	24.35%	-0.08%	0.07%
USA-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	20,632	22,166	24,084	27,893	35,732	39,892	42,055	0.72%	0.83%	3.34%	1.39%	1.06%
YIE1	1.42	1.56	1.60	1.62	2.33	2.55	2.62	0.98%	0.23%	3.17%	1.14%	0.59%
PROP	29,266	34,675	38,549	45,251	83,131	101,649	110,386	1.71%	1.06%	6.61%	2.55%	1.66%
HCPC	4.59	4.63	4.83	4.69	5.30	5.50	5.63	0.09%	0.41%	0.79%	0.45%	0.47%
CONP	917	955	1,023	1,024	1,440	1,582	1,683	0.41%	0.69%	2.89%	1.18%	1.25%
FEEP	#NV	#NV	#NV	#NV	2,941	2,850	2,822	#NV	#NV	#NV	-0.39%	-0.20%
INDP	20,376	21,026	25,403	25,823	44,630	52,159	57,990	0.31%	1.91%	4.81%	1.97%	2.14%
DEMP	23,721	24,891	29,390	30,443	55,512	64,239	71,058	0.48%	1.68%	5.44%	1.84%	2.04%
PEXP	6,574	8,224	12,137	13,739	27,235	39,476	41,659	2.26%	3.97%	6.97%	4.75%	1.08%
PIMP	1,409	1,511	1,195	658	1,444	2,065	2,330	0.70%	-2.32%	1.59%	4.57%	2.44%
USA-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	4,068	4,169	5,044	5,047	9,705	11,214	12,371	0.24%	1.92%	5.60%	1.82%	1.98%
HCPC	13.88	15.24	16.68	17.81	24.66	26.38	27.45	0.94%	0.91%	3.31%	0.84%	0.80%
CONP	2,772	3,143	3,538	3,887	6,702	7,593	8,207	1.26%	1.19%	5.47%	1.57%	1.57%
INDP	0	0	183	55	27	15	16	1.06%	166.76%	-14.72%	-7.08%	1.30%
DEMP	3,699	3,975	4,524	4,794	9,328	10,479	11,284	0.72%	1.30%	6.22%	1.47%	1.49%
PEXP	814	611	1,057	1,008	2,434	2,898	3,361	-2.82%	5.63%	7.20%	2.21%	3.01%
PIMP	377	442	604	847	1,773	2,163	2,274	1.60%	3.17%	9.39%	2.52%	1.01%
USA-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	13,857	15,099	18,555	18,844	34,858	40,744	45,314	0.86%	2.08%	5.39%	1.97%	2.15%
FEEP	11,512	11,930	14,245	14,104	28,258	33,373	36,705	0.36%	1.79%	5.87%	2.10%	1.92%
DEMP	11,530	11,930	14,285	14,196	29,134	34,330	37,701	0.34%	1.82%	6.12%	2.07%	1.89%
PEXP	2,375	3,212	4,281	4,674	6,756	7,910	9,324	3.07%	2.91%	3.88%	1.99%	3.34%
PIMP	48	43	10	26	1,032	1,495	1,711	-1.03%	-13.36%	46.79%	4.74%	2.74%
USA-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	18,394	20,068	21,543	21,368	34,664	39,067	41,478	0.88%	0.71%	4.04%	1.51%	1.20%
HCPC	94.39	101.02	106.16	101.71	117.05	121.47	122.43	0.68%	0.50%	0.82%	0.46%	0.16%
CONP	18,854	20,829	22,519	22,189	31,812	34,967	36,592	1.00%	0.78%	2.92%	1.19%	0.91%
DEMP	18,880	20,864	22,568	22,272	31,986	35,176	36,813	1.00%	-0.79%	2.95%	1.20%	0.91%
PEXP	161	134	132	193	4,081	5,318	6,045	-1.78%	-0.19%	33.11%	3.36%	2.60%
PIMP	666	914	1,163	1,114	1,478	1,428	1,379	3.21%	2.44%	2.02%	-0.43%	-0.70%
USA-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,197	1,297	1,576	1,737	3,644	4,264	4,676	0.80%	1.97%	7.24%	1.98%	1.86%
HCPC	6.16	6.61	7.70	8.37	13.91	15.59	16.52	0.72%	1.53%	5.06%	1.44%	1.17%
CONP	1,230	1,364	1,633	1,826	3,780	4,489	4,936	1.04%	1.82%	7.24%	2.17%	1.92%
DEMP	1,237	1,372	1,643	1,838	3,781	4,490	4,938	1.04%	1.82%	7.19%	2.17%	1.92%
PEXP	3	3	3	4	40	15	15	-0.12%	-0.35%	23.44%	-11.54%	0.00%
PIMP	44	70	73	110	143	241	277	4.68%	0.36%	5.82%	6.74%	2.82%

CAN-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	#NV	#NV	#NV	#NV	19,049	18,822	18,807	#NV	#NV	#NV	-0.15%	-0.02%
YIE1	#NV	#NV	#NV	#NV	2.60	2.91	3.05	#NV	#NV	#NV	1.42%	0.92%
PROP	#NV	#NV	#NV	#NV	49,552	54,794	57,309	#NV	#NV	#NV	1.26%	0.90%
HCPC	90.17	88.88	87.72	87.46	104.22	102.85	105.48	-0.14%	-0.13%	1.45%	-0.17%	0.50%
CONP	1,775	1,835	1,903	1,998	3,154	3,276	3,481	0.34%	0.36%	4.30%	0.48%	1.22%
FEEP	#NV	#NV	#NV	#NV	21,599	22,784	23,987	#NV	#NV	#NV	0.67%	1.03%
INDP	#NV	#NV	#NV	#NV	1,174	1,358	1,312	#NV	#NV	#NV	1.84%	-0.69%
DEMP	17,932	19,621	22,397	22,047	28,684	30,275	31,714	0.90%	1.33%	2.08%	0.68%	0.93%
PEXP	15,816	10,425	17,799	15,433	24,910	28,312	29,584	-4.08%	5.50%	2.84%	1.61%	0.88%
PIMP	658	928	560	1,251	2,097	3,793	3,990	3.49%	-4.92%	11.63%	7.69%	1.02%
CAN-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	1,533	1,569	2,866	2,356	7,010	7,750	7,988	0.23%	6.21%	7.74%	1.26%	0.61%
YIE1	0.88	0.92	1.01	0.98	1.47	1.65	1.73	0.39%	0.95%	3.21%	1.40%	0.96%
PROP	1,354	1,441	2,893	2,302	10,334	12,774	13,813	0.62%	7.22%	11.19%	2.69%	1.58%
HCPC	#NV	#NV	#NV	#NV	7.16	7.73	8.33	#NV	#NV	#NV	0.97%	1.50%
CONP	#NV	#NV	#NV	#NV	216	247	275	#NV	#NV	#NV	1.69%	2.17%
FEEP	#NV	#NV	#NV	#NV	1,062	1,006	1,038	#NV	#NV	#NV	-0.67%	0.63%
INDP	692	757	975	1,030	4,956	5,696	6,116	0.91%	2.57%	14.51%	1.75%	1.43%
DEMP	962	1,081	1,404	1,492	6,701	7,462	7,984	1.18%	2.64%	13.91%	1.35%	1.36%
PEXP	763	775	1,668	1,277	4,479	5,974	6,515	0.16%	7.96%	8.58%	3.67%	1.75%
PIMP	537	475	489	446	599	662	685	-1.24%	0.29%	1.71%	1.26%	0.69%
CAN-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	151	179	244	264	1,737	2,006	2,167	1.74%	3.14%	17.77%	1.82%	1.56%
HCPC	7.75	9.54	10.12	10.89	20.06	20.41	21.05	2.10%	0.60%	5.86%	0.22%	0.62%
CONP	153	197	220	249	607	650	696	2.58%	1.10%	8.84%	0.86%	1.38%
INDP	#NV	#NV	#NV	#NV	12	25	36	#NV	#NV	#NV	9.61%	7.57%
DEMP	238	269	320	368	1,520	1,659	1,794	1.27%	1.72%	13.88%	1.10%	1.58%
PEXP	24	27	58	40	670	803	874	1.23%	8.07%	22.63%	2.29%	1.71%
PIMP	110	117	138	146	317	455	502	0.61%	1.65%	7.17%	4.62%	1.99%
CAN-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	510	557	697	726	3,207	3,667	3,930	0.89%	2.26%	13.57%	1.69%	1.39%
FEEP	491	624	766	854	2,682	3,822	4,561	2.42%	2.08%	11.00%	4.53%	3.60%
DEMP	491	624	766	854	2,682	3,822	4,561	2.42%	2.08%	11.00%	4.53%	3.60%
PEXP	229	151	165	129	1,238	933	722	-4.05%	0.86%	18.30%	-3.47%	-5.00%
PIMP	211	218	225	257	713	1,089	1,352	0.36%	0.29%	10.10%	5.43%	4.43%
CAN-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,736	1,889	2,107	2,161	3,274	3,694	4,031	0.85%	1.10%	3.74%	1.52%	1.76%
HCPC	86.15	91.59	95.85	94.76	91.62	94.86	96.74	0.61%	0.46%	-0.37%	0.43%	0.39%
CONP	1,695	1,891	2,080	2,165	2,773	3,022	3,194	1.10%	0.96%	2.42%	1.08%	1.11%
DEMP	1,739	1,940	2,140	2,222	2,873	3,133	3,307	1.10%	0.99%	2.48%	1.09%	1.09%
PEXP	62	61	103	88	840	1,000	1,159	-0.17%	5.41%	19.08%	2.20%	3.00%
PIMP	70	110	138	147	438	438	433	4.64%	2.24%	10.13%	0.00%	-0.23%
CAN-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	95	107	130	147	350	360	386	1.12%	2.00%	8.60%	0.35%	1.40%
HCPC	4.27	4.94	6.02	7.13	11.48	11.61	11.89	1.48%	2.00%	5.52%	0.14%	0.48%
CONP	84	102	131	163	347	370	392	1.97%	2.51%	8.47%	0.81%	1.16%
DEMP	84	103	132	163	351	374	396	2.00%	2.51%	8.52%	0.80%	1.15%
PEXP	15	16	15	5	23	17	20	0.83%	-1.20%	3.90%	-3.71%	3.30%
PIMP	8	12	16	21	23	31	31	4.81%	2.30%	3.30%	3.80%	0.00%

ROW-Cereals	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	317,749	328,177	328,392	335,494	364,581	371,974	383,796	0.32%	0.01%	0.87%	0.25%	0.63%
YIE1	0.98	1.07	1.16	1.20	1.76	1.97	2.06	0.89%	0.84%	3.50%	1.46%	0.89%
PROP	310,900	350,954	381,850	403,331	640,868	734,374	791,915	1.22%	0.85%	4.41%	1.72%	1.52%
HCPC	143.12	142.71	146.83	145.63	162.03	163.78	165.46	-0.03%	0.29%	0.82%	0.13%	0.20%
CONP	229,183	245,903	271,896	289,623	529,418	624,687	685,923	0.71%	1.01%	5.71%	2.09%	1.89%
FEEP	50,565	62,355	76,771	85,496	128,686	143,771	154,367	2.12%	2.10%	4.40%	1.40%	1.43%
INDP	3,893	4,189	5,010	5,557	10,731	12,470	13,559	0.73%	1.81%	6.55%	1.90%	1.69%
DEMP	329,351	361,489	406,799	436,688	753,688	874,957	954,429	0.94%	1.19%	5.27%	1.88%	1.75%
PEXP	29,329	27,507	27,111	26,820	6,671	6,173	6,057	-0.64%	-0.14%	-11.03%	-0.97%	-0.38%
PIMP	45,005	47,442	52,866	68,540	120,697	146,755	168,570	0.53%	1.09%	7.12%	2.47%	2.81%
ROW-Oilseeds	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
LEVL	65,305	65,437	69,167	70,805	96,455	107,230	113,236	0.02%	0.56%	2.81%	1.33%	1.10%
YIE1	1.19	1.19	1.24	1.30	2.30	2.50	2.64	0.07%	0.40%	5.26%	1.05%	1.09%
PROP	77,491	78,156	85,939	92,247	221,599	267,846	298,656	0.09%	0.95%	8.21%	2.40%	2.20%
HCPC	6.42	6.02	5.97	6.05	8.02	9.39	9.94	-0.64%	-0.10%	2.49%	2.00%	1.15%
CONP	10,277	10,374	11,046	12,025	26,188	35,821	41,239	0.09%	0.63%	7.46%	3.99%	2.86%
FEEP	1,644	1,871	1,975	1,618	3,944	4,069	4,160	1.30%	0.55%	5.93%	0.39%	0.44%
INDP	55,043	55,856	63,470	70,709	188,182	223,389	248,040	0.15%	1.29%	9.48%	2.17%	2.12%
DEMP	71,441	72,923	81,876	90,004	229,009	275,966	307,501	0.21%	1.16%	8.95%	2.36%	2.19%
PEXP	10,029	8,832	8,100	6,615	3,220	6,055	6,696	-1.26%	-0.86%	-7.40%	8.21%	2.03%
PIMP	4,071	3,909	4,181	4,790	11,012	14,175	15,540	-0.41%	0.68%	8.40%	3.21%	1.86%
ROW-Oils	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	10,175	11,035	12,593	14,151	39,143	46,325	51,368	0.81%	1.33%	9.91%	2.13%	2.09%
HCPC	4.85	4.97	5.19	5.53	8.65	8.72	8.86	0.23%	0.43%	4.36%	0.10%	0.31%
CONP	7,772	8,555	9,602	10,997	28,285	33,271	36,707	0.96%	1.16%	9.42%	2.05%	1.99%
INDP	4	4	6	10	59	107	116	0.43%	3.70%	20.51%	7.68%	1.65%
DEMP	9,163	10,005	11,272	12,750	37,062	43,842	48,348	0.88%	1.20%	10.43%	2.12%	1.98%
PEXP	2,469	2,556	3,329	4,487	8,480	9,785	10,920	0.34%	2.68%	8.10%	1.81%	2.22%
PIMP	1,393	1,661	2,206	2,658	6,426	7,301	7,898	1.77%	2.88%	9.32%	1.61%	1.58%
ROW-Cakes	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	12,039	13,054	15,072	17,060	37,897	45,097	50,917	0.81%	1.45%	7.99%	2.20%	2.46%
FEEP	9,239	10,256	11,989	14,297	42,497	49,851	54,992	1.05%	1.57%	11.12%	2.02%	1.98%
DEMP	9,258	10,274	12,009	14,320	42,715	50,095	55,263	1.05%	1.57%	11.15%	2.01%	1.98%
PEXP	3,473	3,729	4,062	4,000	4,659	6,676	8,206	0.71%	0.86%	1.15%	4.60%	4.21%
PIMP	772	905	1,153	1,430	9,660	11,672	12,552	1.60%	2.45%	19.38%	2.39%	1.46%
ROW-Meat	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	18,270	20,548	22,556	24,819	47,169	54,764	59,640	1.18%	0.94%	6.34%	1.88%	1.72%
HCPC	10.95	11.42	11.58	12.07	15.08	15.04	15.06	0.42%	0.15%	2.22%	-0.03%	0.03%
CONP	17,542	19,666	21,456	24,013	49,266	57,387	62,391	1.15%	0.88%	7.17%	1.93%	1.69%
DEMP	17,635	19,770	21,576	24,142	49,783	57,997	63,065	1.15%	0.88%	7.22%	1.93%	1.69%
PEXP	1,246	1,530	1,776	1,688	521	772	922	2.07%	1.50%	-9.72%	5.04%	3.62%
PIMP	628	735	809	1,034	3,104	4,006	4,348	1.58%	0.96%	11.86%	3.24%	1.65%
ROW-CHES	1964 / 66	1974 / 76	1984 / 86	1994 / 96	1997	2005	2010	ggr. 1975	ggr. 1985	ggr. 1995	ggr. 2005	ggr. 2010
PROP	1,073	1,208	1,295	1,438	2,023	2,142	2,205	1.19%	0.70%	3.79%	0.72%	0.58%
HCPC	0.68	0.71	0.71	0.74	0.69	0.63	0.59	0.44%	0.03%	-0.26%	-1.08%	-1.31%
CONP	1,087	1,222	1,318	1,478	2,255	2,414	2,457	1.18%	0.76%	4.58%	0.86%	0.35%
DEMP	1,089	1,224	1,320	1,480	2,270	2,431	2,474	1.18%	0.76%	4.62%	0.86%	0.35%
PEXP	54	67	73	79	141	140	154	2.11%	0.96%	5.61%	-0.09%	1.92%
PIMP	68	86	101	122	388	429	423	2.31%	1.61%	11.88%	1.26%	-0.28%



## **6 - MECOP: A MODEL OF THE EU'S PRODUCING SECTOR OF CEREALS, OILSEEDS AND PROTEIN CROPS**

### **Agenda 2000 and beyond: Impact of reforms of the Common Market Organisation for "grandes cultures"**

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#### **6.1. Introduction**

The objective of this part of the project (i.e., subtask 2.1) was to develop a tool for simulating policy reforms in the arable crop sector of the European Union (EU). This sector plays a central role in the EU agricultural sector, as illustrated by the following figures. In 1996, the contribution of COP products (Cereals, Oilseeds and Protein crops) in EU final agricultural output was roughly 11% and their share in aggregate farm income was estimated at 21%. The total area used for the cultivation of these products accounted for around 42% of the EU Utilised Agricultural Area and 2,75 million holdings were involved in these productions. The rate of EU self-sufficiency was estimated at 120% for cereals, 45% for oilseeds and 80% for protein crops. Finally, the EU is the third most important cereal producer and accounts for 18% of world exports for wheat and 11% for coarse grains. On the other hand, the EU is the most important oilseed importer with 35% of world imports of oilseeds in 1999.

The huge public intervention is another striking feature of this sector. For instance, this sector received in 1999 17 866 millions euros from the European budget or, equivalently, 45% of the European public expenditures for the whole agricultural sector. Since the 1992 CAP reform, a unique Common Market Organisation (CMO) regulates this sector. In a very general way, this 1992 CAP reform reduced cereal price support, removed oilseed price support, introduced compensatory payments based on areas and strengthened supply management measures (set-aside policy). This shift in support mechanism for the arable crop sector partly allowed to conclude the Uruguay Round negotiations on agriculture.

The EU adopted in 1999 a new reform of the CAP, the so-called Agenda 2000 CAP reform. As far as the arable crop sector is concerned, this new reform basically follows the principles of the 1992 CAP reform with new cuts in cereal price support compensated by increased direct payments for cereal areas while direct payments for oilseed areas are reduced to the level of the former. An urgent question

is to determine whether this new version of the CMO for arable crops can be accepted by EU trading partners in the context of the new multilateral trade negotiations at the World Trade Organisation (WTO). In particular, area direct payments cannot be actually challenged at the WTO due to the blue box exemption and the peace clause. However, it is more than likely that this exemption will be under scrutiny during the new round of negotiations. Consequently, CAP area direct payments could be challenged during these negotiations, unless it can be proved that these payments have no, or at most, minimal distortion effects on production and trade, so that they could be qualified as green box measures. Evaluating the consequences of area direct payments on production is therefore of great interest. In the same time, it is also crucial to examine the impacts of the new system on various indicators that are rarely discussed in existing studies, such as the evolution of agricultural income, land return and public expenditures.

To our knowledge, no well-designed model is actually available to deal with these issues. The model developed in this project fills a gap in the stock of research tools available to EU decision makers. Obviously, there already exists several models focused on the arable crop sector, defined either at the European level or at national levels.<sup>94</sup> These models generally differ in terms of product coverage, calibration process, data sources, behavioural relations, etc. Results, given by predictions, simulations or elasticities, are thus not easily comparable, claiming for a new unified framework for all EU Member States. Our model precisely is implemented at the national level for various European Union Member States, which are the main COP crop-producing countries, and thus offers this advantage, while keeping enough flexibility in order to take account of the particularities of each EU Member State.

We label our model MECOP where the acronym stands for Maximum Entropy on Cereals, Oilseeds and Protein crops. In a general way, this model describes the behaviour of agricultural producers with respect to the supply of COP crops, the allocation of land across these crops and their decision in yield levels. The main policy instruments of the CMO for arable crops, i.e. the direct payment system, the set-aside requirement, etc. are explicitly incorporated in the model. This permits the evaluation of the effects of these instruments on the decision variables of arable crop producers. As such, impacts on production levels of previous reforms of the arable crop CMO (in particular the 1992 or MacSharry reform) may be simulated with the MECOP model. In the same vein, MECOP allows to assess the likely future impacts of the Agenda 2000 CAP reform and, of great importance, the potential effects of propositions that may emerge during the WTO talks. This is a crucial feature of the MECOP model since the objectives of this FAIR programme were to clearly understand the process by which policy

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<sup>94</sup> For example, MacQuinn (2000) for Ireland, Judez et al. (1999) for Spain, Moro and Sckokai (1998) for Italy, Jensen (1996) for Denmark, Guyomard et al. (1996) for France, Oude Lansink and Peerlings (1996) for The Netherlands, Cahill (1997) for the UE12. This list is obviously non exhaustive.

changes impact on supply, derived demand, final demand and trade as well as to provide policy makers with sound economic and policy-oriented analyses to back their proposals in these talks.

Our model has been specified according to some clearly defined scientific principles. The developed specification is strongly based on production theory. The producer's problem is to select levels of variable inputs and allocate total land among COP crops in order to maximise profits subject to technical and market constraints. Market constraints are captured by input and output price vectors and agricultural policy instruments. We use the duality theory to represent technical constraints and we assume that land is a quasi-fixed but allocatable factor.

As the name of the model suggests, behavioural parameters specified in this model are calibrated in a stochastic manner using the Generalised Maximum Entropy (GME) econometric technique. This technique is more and more widely used in empirical studies because it reveals more appropriate in some circumstances than other "traditional" techniques, such as the least square or maximum likelihood ones. In particular, when collinearity between exogenous variables is strong, traditional econometric estimators are highly unstable while it has been proved that GME estimators are much more efficient. In the case of the MECOP model, we observe strong collinearity between COP crop prices, making judicious the choice of the GME technique.

The theoretical model is applied to six European countries: Denmark, Germany, France, Italy, Spain and UK. Nine COP crops are distinguished: five cereals (soft wheat, barley, maize, oat and rye), three oilseeds (rape, sunflower and soya) and one protein crop (field peas). Parameter estimation is carried over 1973-1999 using annual data supplied by Eurostat.

This chapter is organised as follows. Section 2 deals with the theoretical aspects of the MECOP model. We explain the specification of behavioural relationships (supply functions, land allocation functions, etc.). They derive from an explicit optimisation program which incorporates the main policy instruments of the arable crop CMO. Section 3 is devoted to the estimation framework based on the GME approach. The principles of the GME econometric technique are first briefly reminded and then we discuss the implementation of this technique for the MECOP model. Estimation results are presented and discussed in section 4. In section 5, we define policy experiments and analyse results. Finally, section 6 concludes, providing some policy recommendations.

## 6.2. Theoretical framework

The modelling of the behaviour of agricultural producers has received considerable attention from agricultural economists, notably since the 1992 CAP reform. Many methodological approaches have been investigated in the literature. The theoretical foundation of the MECOP model is the duality theory in the presence of allocatable quasi-fixed factors.<sup>95</sup>

### 6.2.1. Preliminaries: The duality theory under allocatable quasi-fixed factor

Consider a multi-output firm with a fixed amount of an allocatable quasi-fixed factor  $\bar{L}$  that can be devoted to  $I$  enterprises. We assume that technologies of enterprises  $i = 1, \dots, I$  are disjoint, i.e. the production technology is non-joint in variable inputs but is characterised by the existence of an allocatable quasi-fixed factor. The producer's problem is to select levels of  $N$  variable inputs for each of the  $I$  enterprises and to allocate the quasi-fixed factor among them. Assuming that the producer is a price taker in the output and variable input markets, its profit-maximising program may be written as:

$$\pi(p, w, \bar{L}) = \max_{y_i, x_{n,i}, l_i} \left[ \sum_{i=1}^I p_i y_i - \sum_{n=1}^N \sum_{i=1}^I w_n x_{n,i}; y_i = f^i(x_{n,i}, l_i); \sum_{i=1}^I l_i = \bar{L} \right] \quad (1)$$

where  $y$  is the vector of the  $I$  outputs,  $p$  is the corresponding price vector,  $x$  is the vector of the  $N$  variable inputs,  $w$  is the corresponding price vector,  $l$  is the vector of the quantities of the quasi-fixed factor allocated to the  $I$  enterprises and  $f^i(x_{n,i}, l_i)$  is a concave production function for enterprise  $i$ . This program defines a restricted profit function which is linearly homogeneous and convex in prices, monotonically increasing in output prices, monotonically decreasing in variable input prices, and monotonically increasing in the allocatable quasi-fixed factor.

Due to the separability assumption of the production technology with respect to variable inputs, this program may be solved in two stages. In the first stage, the optimal quantities of variable inputs and outputs are determined for a given allocation of the quasi-fixed factor. The program corresponding to this first stage may be written as:

$$\pi^i(p_i, w, l_i) = \max_{y_i, x_{n,i}} \left[ p_i y_i - \sum_{n=1}^N w_n x_{n,i}; y_i = f^i(x_{n,i}, l_i) \right] \quad \forall i = 1, \dots, I \quad (2)$$

We then obtain an output-specific profit function which measures the quasi-rent to the allocatable quasi-fixed factor. This function is linearly homogeneous and convex in prices, monotonically

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<sup>95</sup> For a presentation or applications of this approach, see, among others, Just et al. (1983), Shumway et al. (1984), Chambers and Just (1989), Moschini (1989), Coyle (1993), Jensen and Lind (1993), Oude Lansink and Peerlings (1996), Guyomard et al. (1996), Ball et al. (1997).

increasing in output prices, monotonically decreasing in variable input prices, and monotonically increasing and concave in the allocation of the quasi-fixed factor. The latter property implies that the quasi-rent is decreasing in the amount of the quasi-fixed factor. In the second stage, the optimal allocation of the quasi-fixed factor between the  $I$  enterprises is obtained by solving the following maximisation program:

$$\pi(p, w, \bar{L}) = \max_{l_i} \left[ \sum_{i=1}^I \pi^i(p_i, w, l_i); \sum_{i=1}^I l_i = \bar{L} \right] \quad (3)$$

Assuming interior solutions, the first-order conditions of the producer's program are:

$$\partial \pi^i(p_i, w, l_i) / \partial l_i - \lambda = 0 \quad \forall i = 1, \dots, I \quad (4)$$

$$\sum_{i=1}^I l_i = \bar{L} \quad (5)$$

where  $\lambda$  is the Lagrange multiplier associated with the constraint resulting from the fixed total amount of the allocatable quasi-fixed factor. From conditions (4), we observe that, at the optimum of the multi-product firm, the shadow prices or marginal quasi-rents of the allocatable quasi-fixed factor are equalised across the  $I$  enterprises. Conditions (4) and (5) defines a square system of  $I+1$  endogenous variables and equations. Solving this system yields:

$$\lambda(\cdot) = \lambda(p, w, \bar{L}) \quad (6)$$

$$l_i(\cdot) = l_i(p, w, \bar{L}) \quad \forall i = 1, \dots, I \quad (7)$$

Thus the optimal allocation of the quasi-fixed factor as well as its shadow price depend on all output prices, variable input prices and the total amount of the allocatable quasi-fixed factor. The comparative statics of these endogenous variables are given by:

$$d\lambda = \left[ \sum_{i=1}^I (\pi_{l_i l_i}^i)^{-1} \right]^{-1} \left[ d\bar{L} + \sum_{i=1}^I (\pi_{l_i l_i}^i)^{-1} \pi_{l_i p_i}^i dp_i + \sum_{n=1}^N \sum_{i=1}^I (\pi_{l_i l_i}^i)^{-1} \pi_{l_i w_n}^i dw_n \right] \quad (8)$$

$$\begin{aligned} dl_i &= (\pi_{l_i l_i}^i)^{-1} \left[ \sum_{j=1}^I (\pi_{l_j l_j}^j)^{-1} \right]^{-1} d\bar{L} \\ &\quad - (\pi_{l_i l_i}^i)^{-1} \pi_{l_i p_i}^i dp_i + (\pi_{l_i l_i}^i)^{-1} \left[ \sum_{j=1}^I (\pi_{l_j l_j}^j)^{-1} \right]^{-1} \sum_{j=1}^I (\pi_{l_j l_j}^j)^{-1} \pi_{l_j p_j}^j dp_j \\ &\quad - \sum_{n=1}^N (\pi_{l_i l_i}^i)^{-1} \pi_{l_i w_n}^i dw_n + (\pi_{l_i l_i}^i)^{-1} \left[ \sum_{j=1}^I (\pi_{l_j l_j}^j)^{-1} \right]^{-1} \sum_{n=1}^N \sum_{j=1}^I (\pi_{l_j l_j}^j)^{-1} \pi_{l_j w_n}^j dw_n \quad \forall i = 1, \dots, I \end{aligned} \quad (9)$$

where  $\pi_{kk}^i$  are the second order derivatives of the output-specific profit functions. From the properties of these output-specific profit functions mentioned above, we can infer that the shadow price is

decreasing in the amount of the quasi-fixed factor, increasing in the prices of outputs if the quasi-fixed factor is non-inferior. Moreover, this shadow price is homogeneous of degree one in output and variable input prices. However, the sign of the effect of variable input prices on the shadow price is indeterminate. Equation (9) provides the comparative statics of the optimal allocation of the quasi-fixed factor. Allocation of the quasi-fixed factor to one given enterprise is an increasing function of the total amount of this quasi-fixed factor and of the price of the corresponding output, again under the assumption of non-inferiority of the quasi-fixed factor. It is a decreasing function of the price of other outputs. Finally, it is homogeneous of degree zero in prices. The sign of the effect of variable input prices on the optimal allocation is also indeterminate.

Finally, output supply and variable input derived demand functions are obtained by applying Hotelling's lemma to each output-specific profit function evaluated at the optimal allocation of the quasi-fixed factor:

$$y_i(\cdot) = y_i(p_i, w, l_i(p, w, \bar{L})) = \partial \pi^i(p_i, w, l_i(p, w, \bar{L})) / \partial p_i \quad \forall i = 1, \dots, I \quad (10)$$

$$x_{n,i}(\cdot) = x_{n,i}(p_i, w, l_i(p, w, \bar{L})) = -\partial \pi^i(p_i, w, l_i(p, w, \bar{L})) / \partial w_n \quad \forall n = 1, \dots, N; \forall i = 1, \dots, I \quad (11)$$

Despite the assumption of non-jointness in variable inputs, we must underline that these output supply and variable input derived demand functions depend again on all output prices, variable input prices and the amount of the allocatable quasi-fixed factor, through the allocation of the quasi-fixed factor. Their comparative statics are given by:

$$dy_i = \pi_{p_i p_i}^i dp_i + \sum_{n=1}^N \pi_{p_i w_n}^i dw_n + \pi_{p_i l_i}^i dl_i \quad \forall i = 1, \dots, I \quad (12)$$

$$dx_{n,i} = -\pi_{w_n p_i}^i dp_i - \sum_{m=1}^N \pi_{w_n w_m}^i dw_m - \pi_{w_n l_i}^i dl_i \quad \forall n = 1, \dots, N; \forall i = 1, \dots, I \quad (13)$$

Supply of a given output is increasing in its own price and in the amount of quasi-fixed factor, decreasing in other output prices, under the assumption of non-inferiority of the quasi-fixed factor. This supply function is also homogeneous of degree zero in output and variable input prices. The sign of the effect of variable input prices on output supply is still indeterminate. By symmetry, the sign of the effect of output prices on the derived demands of variable inputs is also ambiguous. The derived demands of variable inputs are homogeneous of degree zero in output and variable input prices and decreasing in their own price.

This methodological approach displays several attractive features. Firstly, the relevance of this multi-product framework to agricultural production is readily apparent. For a producer specialised in arable crop farming, this approach can represent a land allocation problem, where a fixed farm acreage can

be devoted to alternative crops. This could also represent a production model of the agricultural sector, with the quasi-fixed factor being the total available land for a region or a country. Secondly, the dual approach to the specification of a system of output supplies, variable input derived demands and land allocations has well known advantages over estimation of a single output supply or acreage response equation (Coyle, 1993). In particular, the dual system approach permits the incorporation of theoretical restrictions on coefficients across equations implied by hypotheses of competitive profit maximisation and also the recovery of the underlying technology. Furthermore, the duality approach provides other advantages when empirical estimation of behavioural parameters is considered. In a primal approach, production and/or transformation functions can be estimated directly. However, as pointed out by Varian (1984) or Chambers and Just (1989), it has been difficult to find a functional specification of the production technology which is simple enough to be estimated directly and does not impose too many a priori restrictions on economic parameters. On the other hand, the duality approach yields the option of larger flexibility in econometric description by allowing the use of flexible functional forms. Thirdly, if land is the allocatable quasi-fixed factor, yields are determined endogenously while in many approaches, especially with mathematical programming models, these yields are often assumed to be constant. Yields are given by:

$$r_i(.) = y_i(p, w, \bar{L}) / l_i(p, w, \bar{L}) = r_i(p, w, \bar{L}) \quad (14)$$

They are homogeneous of degree zero in output and variable input prices. However, the effects of exogenous variables are a priori indeterminate. Fourthly, policy instruments can be incorporated explicitly in that framework. For instance, Moro and Sckokai, Oude Lansink and Peerlings or Guyomard et al. have introduced in different ways the policy instruments of the arable crop CMO in their model and we will discuss below our own modelling of arable crop CMO instruments.

Despite this appealing features, this framework has not been applied, up to now, to the arable crop sector of all EU Member States. One possible explanation lies in the difficulty to estimate econometrically the behavioural parameters of the system of output supplies, variable input derived demands and allocation of the quasi-fixed factor. This difficulty results from the multicollinearity between output prices. As underlined by Coyle (1993), all crop acreage allocation functions are seldom estimated simultaneously and moreover all output prices are not included in these functions. However, we must note that the GME econometric technique is well-suited in such context, facilitating the application of this framework to the arable crop sector of various EU member states.

### 6.2.2. The theoretical structure of the MECOP model

For the MECOP model, we apply the duality theory under allocatable quasi-fixed factor reviewed above. We assume that land is the only allocatable quasi-fixed factor between  $I$  COP crop enterprises of a representative farm for each EU Member State. The number of considered activities will depend on the EU Member State and therefore will be defined later. However, for all of them, we assume the existence of only one aggregate variable input ( $N=1$ ) due to data constraints. We explicit the first stage of the optimisation process before turning to the second one.

#### 6.2.2.1. The first stage

COP crop-specific profit functions are approximated by Normalised Quadratic (NQ) forms defined on normalised output prices ( $p_i / w$ ). Thus, they can be written as:

$$\begin{aligned} \pi^{i,t}(p_{i,t}, w_t, l_{i,t}, t) = & \theta_i + b_i l_{i,t} + c_i \frac{p_{i,t}}{w_t} + \xi_i t \\ & + 0.5d_i \left( \frac{p_{i,t}}{w_t} \right)^2 + 0.5e_i l_{i,t}^2 + 0.5\psi_i t^2 \\ & + f_i \frac{p_{i,t}}{w_t} l_{i,t} + g_i l_{i,t} t + h_i \frac{p_{i,t}}{w_t} t \quad , \forall i = 1, \dots, I \end{aligned} \quad (15)$$

where  $\theta_i, b_i, c_i, d_i, e_i, f_i, g_i, h_i, \xi_i, \psi_i$  are behavioural parameters to be estimated and  $t$  is the index for the years included in the analysis.

The specification of this restricted profit function deserves several remarks. Firstly, a time trend is included as an explanatory variable and is assumed to represent the effects of technical change on profits, output supplies, variable input derived demands and land allocations. This specification of technical change is quite arbitrary but is commonly adopted in empirical work.

Secondly, the choice of the NQ functional form is driven by practical considerations. As will become clear later, use of this flexible functional form permits a closed-form solution to acreage allocations insofar as the equation system composed of (4) and (5) is linear.

Thirdly, the behavioural parameters listed above must satisfy some constraints in order to fulfil the theoretical requirements of output-specific profit functions. These constraints are:

$$d_i \geq 0, \forall i = 1, \dots, I \quad (16)$$

$$e_i \leq 0, \forall i = 1, \dots, I \quad (17)$$

$$f_i \geq 0, \forall i = 1, \dots, I \quad (18)$$

Constraints (16) ensure the convexity in prices of the output-specific profit functions. Constraints (17) ensure the concavity in the land allocation of these functions. Finally, if we assume that land is a non-inferior input, then constraints (18) must hold.

Fourthly, by applying Hotelling's lemma to these profit functions, one obtains the supply functions for a given land allocation:

$$y_{i,t}(p_{i,t}, w_t, l_{i,t}, t) = c_i + d_i \frac{p_{i,t}}{w_t} + f_i l_{i,t} + h_i t, \quad \forall i = 1, \dots, I \quad (19)$$

These supply functions are linear in parameters and in explanatory variables.

Fifthly, we assume that agricultural producers make naïve price expectations. In other words, expected prices are supposed to be equal to past prices.

#### 6.2.2.2. *The second stage*

We now turn to the second stage of the optimisation process, which focuses on the land allocation decision. With the 1992 CAP reform, internal support for arable crop growers has significantly changed. The Agenda 2000 CAP reform basically deepens this change. In a general way, these reforms involve significant support price reductions, compensated by area direct payments and a land set-aside scheme. The direct payment and land set-aside programs are highly complex as they include many exemptions or special cases. For instance, the levels of area direct payments differ between COP crops and regions because they are based on historical regional average yields and historical crop areas. Furthermore, these area direct payments are contingent upon idling a certain proportion of historical base areas for "professional" producers, i.e., those with an area more than that needed to grow 92 tonnes of cereals. On the other hand, "small" producers need not set aside part of their arable crop area in order to qualify for area direct payments. Moreover, the levels of area direct payments can be revised, depending whether maximum eligible areas are exceeded or not. The land set-aside scheme also includes many particularities. We can distinguish between the rotational, non-rotational and voluntary set-aside programs, which differ with respect to the rate of set-aside. Consequently, producers located in different regions or endowed with different land resources are affected in different ways by these reforms.

These intricate mechanisms are necessarily captured in an imperfect manner in the MECOP model, which is designed at the national level. Nevertheless, MECOP provides "average" indicators which are quite useful for policy makers. These policy mechanisms are explicitly introduced in the second stage of the optimisation program for the representative farm, which is given by:

$$\pi'(p_i, w_i, \bar{L}_i, a_i, \alpha_i, t) = \max_{l_{i,t}} \sum_{i=1}^I \pi^{i,t}(p_{i,t}, w_i, l_{i,t}, t) + a_{i,t} / w_i l_{i,t} + af_i / w_i lf_i \quad (20)$$

$$\text{subject to: } \sum_{i=1}^I l_{i,t} + lf_i \leq \bar{L}_i \quad (21)$$

where average area direct payment for crop  $i$  is denoted by  $a_{i,t}$ ,  $\bar{L}_i$  is the total land available for crop-farming and set-aside,  $af_i$  is the average area direct payment for idle land and  $lf_i$  is the idle land. We assume here that this area is exogenous and corresponds to a policy instrument. The objective function is the sum of COP crop-specific profit functions augmented by direct payments on cultivated and idle lands. Constraint (21) expresses the total land constraint.

Replacing the COP crop-specific profit functions by their expressions (15), the lagrangian corresponding to this program is:

$$L(l_{i,t}, \lambda_i) = \sum_{i=1}^I \left[ \begin{aligned} &\theta_i + b_i l_{i,t} + c_i \frac{p_{i,t}}{w_i} + \xi_i t \\ &+ 0.5 d_i \left( \frac{p_{i,t}}{w_i} \right)^2 + 0.5 e_i l_{i,t}^2 + 0.5 \psi_i t^2 \\ &+ f_i \frac{p_{i,t}}{w_i} l_{i,t} + g_i l_{i,t} t + h_i \frac{p_{i,t}}{w_i} t \end{aligned} \right] + \sum_{i=1}^I \frac{a_{i,t}}{w_i} l_{i,t} + \frac{af_i}{w_i} lf_i + \frac{\lambda_i}{w_i} \left( \bar{L}_i - \sum_{i=1}^I l_{i,t} - lf_i \right) \quad (22)$$

The first-order Kuhn and Tucker conditions for this program are:

$$b_i + e_i l_{i,t} + f_i \frac{p_{i,t}}{w_i} + g_i t + \frac{a_{i,t}}{w_i} - \frac{\lambda_i}{w_i} \leq 0 \quad \perp \quad l_{i,t} \geq 0 \quad \% \quad (23)$$

$$\sum_{i=1}^I l_{i,t} + lf_i - \bar{L}_i \leq 0 \quad \perp \quad \lambda_i \geq 0 \quad (24)$$

Conditions (23) imply that a particular crop is cultivated only if the marginal profit of land allocated to that crop, which includes the area direct payment, equals the normalised land shadow price. One crop is not cultivated if this marginal profit is strictly lower than the normalised land shadow price. Finally, one may observe that this marginal profit can not be greater than the normalised land shadow price. Conditions (24) show that the land shadow price is strictly positive only if total available land for cropping (i.e. total land less mandatory set aside) is cultivated.

Before the 1992 CAP reform, the system of conditions (23)-(24) reduces to:

$$\begin{cases} b_i + e_i l_{i,t} + f_i \frac{p_{i,t}}{w_i} + g_i t - \frac{\lambda_i}{w_i} \leq 0 \quad \perp \quad l_{i,t} \geq 0 \\ \sum_{i=1}^I l_{i,t} - \bar{L}_i \leq 0 \quad \perp \quad \lambda_i \geq 0 \\ l f_i = 0, a f_i = 0, a_{i,t} = 0 \end{cases} \quad (25)$$

Assuming interior solutions, this system leads to:

$$\frac{\lambda_i}{w_i} = \frac{\bar{L}_i + \sum_{i=1}^I \left( \frac{b_i + f_i \frac{p_{i,t}}{w_i} + g_i t}{e_i} \right)}{\sum_{i=1}^I 1/e_i} > 0 \quad (26)$$

$$l_{i,t} = \frac{1}{e_i} \left[ \frac{\bar{L}_i + \sum_{j=1}^I \left( \frac{b_j + f_j \frac{p_{j,t}}{w_j} + g_j t}{e_j} \right)}{\sum_{j=1}^I 1/e_j} - b_i - f_i \frac{p_{i,t}}{w_i} - g_i t \right] > 0 \quad (27)$$

From the constraints (16)-(18) on behavioural parameters, one can easily check that the normalised land shadow price is decreasing in the total amount of land, increasing in the prices of outputs and homogeneous of degree one in output and variable input prices. Land allocated to one COP crop is an increasing function of the total amount of land and of the price of the corresponding output. It is a decreasing function of the price of other outputs and is homogeneous of degree zero in prices. The effect of the variable input price on land allocation is indeterminate.

After the implementation of the 1992 CAP reform, the level of endogenous variables are given by (always assuming an interior solution):

<sup>96</sup> This notation stands for complementary slackness:  $(x \geq 0 \quad \perp \quad y \geq 0) \Leftrightarrow (x \geq 0, y \geq 0, xy = 0)$ .

$$\frac{\lambda_t}{w_t} = \frac{\bar{L}_t - lf_t + \sum_{i=1}^I \left( \frac{b_i + f_i \frac{p_{i,t}}{w_t} + g_i t + \frac{a_{i,t}}{w_t}}{e_i} \right)}{\sum_{i=1}^I 1/e_i} \geq \frac{af_t}{w_t} > 0 \quad (28)$$

$$l_{i,t} = \frac{1}{e_i} \left[ \frac{\bar{L}_t - lf_t + \sum_{j=1}^I \left( \frac{b_j + f_j \frac{p_{j,t}}{w_t} + g_j t + \frac{a_{j,t}}{w_t}}{e_j} \right)}{\sum_{j=1}^I 1/e_j} - b_i - f_i \frac{p_{i,t}}{w_t} - g_i t - \frac{a_{i,t}}{w_t} \right] > 0 \quad (29)$$

Equations (28) and (29) show that the set-aside requirement has a positive effect on the normalised land shadow price and a negative effect on land allocated to each crop. Direct payments for cultivated crops have a positive effects on the normalised land shadow price. We can also observe that acreage allocation to one given crop is an increasing function of its own direct payment and a decreasing function of direct payments for all other crops. The direct payment for idle land has no effect on these variables but only on the opportunity cost of the set-aside requirement (cf. equation 28). Finally, we must note that the effects of the prices and the total available land are as described before.

### 6.2.3. Miscellaneous by-products of the MECOP model

In addition to the previously described COP crop supply functions (equations 19), land allocation functions (equations 27 for the cultivated areas before the 1992 CAP reform; equations 29 for the cultivated areas after the 1992 CAP reform) and the land shadow price function (equations 26 and 28), several other interesting results may be derived from the MECOP model.

Firstly, as indicated above, yields are obtained by dividing output supply by corresponding cultivated areas:

$$r_{i,t}(\cdot) = f_i + \left( c_i + d_i \frac{p_{i,t}}{w_t} + h_i t \right) / l_{i,t}(\cdot) \quad , \forall i = 1, \dots, I \quad (30)$$

Secondly, public expenditures induced by area direct payments can be computed for each COP crop (they are denoted by  $PE_{i,t}$ ) and for the entire arable crop CMO (they are denoted by  $PE_t$ ):

$$PE_{i,t} = a_{i,t} l_{i,t} \quad (31)$$

$$PE_t = \sum_{i=1}^I PE_{i,t} + af_t l_f \quad (32)$$

Thirdly, elasticities of output supplies and land allocations with respect to output prices, direct payments and total available land can also be computed. The levels of these elasticities depend on the year. Their expressions are given below for one year after the implementation of the 1992 CAP reform.

$$\begin{aligned} \varepsilon_{p_{i,t}}^{l_{i,t}} &= \frac{f_i}{e_i} \left( \frac{1/e_i}{\sum_{k=1}^I 1/e_k} - 1 \right) \frac{p_{i,t}/w_t}{l_{i,t}} \geq 0 & \varepsilon_{p_{i,t}}^{y_{i,t}} &= d_i \frac{p_{i,t}/w_t}{y_{i,t}} + \frac{f_i l_{i,t}}{y_{i,t}} \varepsilon_{p_{i,t}}^{l_{i,t}} \geq 0 \\ \varepsilon_{p_{j,t}}^{l_{i,t}} &= \frac{f_j}{e_j} \frac{1/e_i}{\sum_{k=1}^I 1/e_k} \frac{p_{j,t}/w_t}{l_{i,t}} \leq 0 & \varepsilon_{p_{j,t}}^{y_{i,t}} &= \frac{f_j l_{i,t}}{y_{i,t}} \varepsilon_{p_{j,t}}^{l_{i,t}} \leq 0 \\ \varepsilon_{a_{i,t}}^{l_{i,t}} &= \frac{1}{e_i} \left( \frac{1/e_i}{\sum_{k=1}^I 1/e_k} - 1 \right) \frac{a_{i,t}/w_t}{l_{i,t}} \geq 0 & \varepsilon_{a_{i,t}}^{y_{i,t}} &= \frac{f_i l_{i,t}}{y_{i,t}} \varepsilon_{a_{i,t}}^{l_{i,t}} \geq 0 \\ \varepsilon_{a_{j,t}}^{l_{i,t}} &= \frac{1}{e_j} \frac{1/e_i}{\sum_{k=1}^I 1/e_k} \frac{a_{j,t}/w_t}{l_{i,t}} \leq 0 & \varepsilon_{a_{j,t}}^{y_{i,t}} &= \frac{f_j l_{i,t}}{y_{i,t}} \varepsilon_{a_{j,t}}^{l_{i,t}} \leq 0 \\ \varepsilon_{L_t}^{l_{i,t}} &= \frac{1/e_i}{\sum_{k=1}^I 1/e_k} \frac{\bar{L}_t}{l_{i,t}} \geq 0 & \varepsilon_{L_t}^{y_{i,t}} &= \frac{f_i l_{i,t}}{y_{i,t}} \varepsilon_{L_t}^{l_{i,t}} \geq 0 \\ \varepsilon_{l_f}^{l_{i,t}} &= -\varepsilon_{L_t}^{l_{i,t}} \leq 0 & \varepsilon_{l_f}^{y_{i,t}} &= -\varepsilon_{L_t}^{y_{i,t}} \leq 0 \end{aligned} \quad (33)$$

Finally, we can insulate the impacts of each explanatory variable on endogenous variables. For instance, the impacts of the trend on cultivated areas, output supplies and yields are given by:

$$\begin{aligned} \frac{\partial l_{i,t}}{\partial t} &= \frac{1}{e_i} \left( \frac{\sum_{j=1}^I g_j / e_j}{\sum_{j=1}^I 1/e_j} - g_i \right) & \frac{\partial y_{i,t}}{\partial t} &= f_i \frac{\partial l_{i,t}}{\partial t} + h_i \\ \frac{\partial r_{i,t}}{\partial t} &= \frac{1}{l_{i,t}} \left( (f_i - r_{i,t}) \frac{\partial l_{i,t}}{\partial t} + h_i \right) \end{aligned} \quad (34)$$

### 6.3. Estimation framework: The Generalised Maximum Entropy

In order to implement the MECOP model, we need to calibrate the behavioural parameters involved in the COP crop supply and land allocation functions. These parameters are:  $b, c, d, e, f, g, h$ , so that we have 7\*I parameters for each EU Member State.<sup>97</sup> One can easily check that data required to calibrate these parameters are limited to production levels, output and input prices, cultivated and idle areas, direct payments and set-aside rates. The Eurostat CRONOS database provides series for the first three variables for most EU Member States over the period 1973-1997. The two others are taken from ONIC (Office National Interprofessionnel des Céréales).

Ideally, output supply, land allocation and land shadow price equations should be estimated simultaneously in order to incorporate restrictions on coefficients across equations and to obtain maximum estimation efficiency. However, applications of the iterative Three-Stage Least Squares (3SLS) procedure, as well as the Full Information Maximum Likelihood (FIML) procedure, lead to unstable estimates because explanatory variables, especially output prices, are highly collinear. Precisely, the design matrix made of explanatory variables does not have a numerically stable inverse matrix, such as traditional estimators have high variances. This in turn results in small changes in the data potentially leading to large changes in parameter estimates, increased variation in parameter estimates (wrong signs/implausible magnitudes), tests of hypotheses about parameters having little power and finally a general lack of faith in inference procedures.

This situation has motivated our choice of the GME econometric technique which leads to estimators with higher degree of precision. We first remind the principles of this technique before explaining its implementation for the MECOP model.

#### 6.3.1. The Generalised Maximum Entropy approach

The Maximum Entropy (ME) econometric technique has been used in empirical economic work for several years but the number of applications has recently boomed with the publication of the book "Maximum Entropy Econometrics: Robust Estimation with Limited Data" written by Golan, Judge and Miller (GJM) in 1996. There also exist several theoretical papers looking at the properties of this technique, providing some refinements or comparing ME with "traditional" econometric approaches. In this section, we first expose the principles of the ME, next describe the GME approach and finally provide a general discussion.<sup>98</sup>

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<sup>97</sup> The other parameters specified in the COP crop profit functions are not estimated due to lack of data concerning profit levels.

<sup>98</sup> The materials in this section draws heavily upon the numerous works of Perloff et al. and Fraser (1999).

### 6.3.1.1. Principles of the Maximum Entropy

The entropy-information measure of Shannon (1948) reflects the uncertainty we have about the occurrence of a collection of events. Let define  $x$  a random variable with possible outcomes  $x_s, s = 1, \dots, n$  with probabilities  $px_s$  satisfying  $\sum_{s=1}^n px_s = 1$ . Shannon defines the entropy of the distribution  $px$  as:

$$H(px) \equiv -\sum_{s=1}^n px_s \log(px_s) \quad (35)$$

To understand this function, suppose that we have a sample of  $T$  draws of the identically and independently distributed random variable  $x$ . Because the draws are independent, a list of the number of times each value occurs contains all information this experiment provides about the random variable. The order contains no information about the probabilities. Let define the outcome of an experiment as a vector  $f = (f_1, \dots, f_n)$  where  $f_s$  is the number of times  $x_s$  occurs. We have:

$\sum_{s=1}^n f_s = T$  and  $px_s = \frac{f_s}{T}$ . A particular outcome may be obtained in a number of ways. For example,

the outcome  $(1, T-1, 0, \dots, 0)$  can occur in  $T$  possible ways. Let define  $v(f)$  as the number of ways that a particular outcome can occur. This is given by the multinomial coefficient  $W(T, px)$ :

$$W(T, px) = \frac{T!}{\prod_{s=1}^n f_s!} = \frac{T!}{\prod_{s=1}^n Tpx_s!} \quad (36)$$

Suppose that we have no information about the draws and are asked which outcome is the most likely. An "intuitive reasonable" response is that the outcome that can occur in the most number of ways is the most likely outcome. Therefore, the most likely outcome is given by maximising  $W$ , which is directly related to the Shannon entropy measure:<sup>99</sup>

$$H(px) \approx T^{-1} \ln W(T, px) \quad (37)$$

Therefore, by maximising the entropy function, we maximise the number of possible permutations that result in a given outcome.

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<sup>99</sup> This relation is obtained using Stirling's approximation.

Based on the Shannon entropy measure, Jaynes (1957) proposed a way by which to recover the unknown probabilities of a distribution. Suppose now that we know some particular moments (for instance the mean or variance) of a probability distribution. Obviously two or more probability distributions could have generated these moments. Given that two or more might satisfy this constraint or information, Jaynes suggested to select the one which is least informative, or most uncertain according to the Shannon entropy criterion. Equivalently, the selected distribution is the one which can be obtained by the most number of ways. The derived solution then agrees with the known information but expresses maximal uncertainty in relation to other things.

To sum-up, the Shannon entropy function gives the frequency distribution that may be generated in the largest number of ways in repeated sampling. Maximum entropy methods were developed by Jaynes to recover an unknown probability distribution from given moment constraints. Jaynes proposed selecting the probability distribution that satisfies the moment constraints and maximises Shannon's entropy criterion. In other words, according to Jaynes, the maximum entropy distribution agrees with what is known but expresses maximum uncertainty with respect to all other matters.

#### *6.3.1.2. The Generalised Maximum Entropy*

The main contributions of GJM have been to generalise the ME formalism in order to solve standard econometric problems and to derive the properties of the GME estimators. In the traditional ME approach, sample information in the form of moment conditions is assumed to hold exactly. In contrast, the GME approach uses each observation directly while allowing these moment conditions to hold only approximately by treating them as stochastic restrictions. Let consider the standard linear model:

$$y = X\beta + e \tag{38}$$

where  $y$  is a  $(T*1)$  vector of endogenous variables,  $X$  is the  $(T*K)$  design matrix,  $\beta$  is a  $(K*1)$  vector of unknown parameters and  $e$  is a  $(T*1)$  vector of disturbances. It is clear that many vectors  $\beta$  and  $e$  satisfy the linear regression equations (38). The GME approach allows to choose one of them. Because the arguments of the Shannon entropy function are probabilities, parameters and disturbances must be written as proper probability distributions defined over some supports. By the way, we can note that specifying the supports is similar to imposing prior restrictions in the Bayesian method or in the mixed estimation framework. Thus, implementation of the GME technique starts by choosing a set of discrete points, called the support space, for all parameters and disturbances.

Specifically, we convert each parameter as follows:

$$\beta_k = \sum_{m=1}^{M_k} p_{km} z_{km} \quad (39)$$

where  $p_k$  is a  $M_k$ -dimensional proper probability vector corresponding to a  $M_k$ -dimensional vector of weights  $z_k$ .<sup>100</sup> This last vector defines the support space of  $\beta_k$ . Therefore each parameter is converted from the real line into a well-behaved set of proper probabilities defined over the supports. The issue related to the definition of these supports is discussed later. Similarly, we transform the disturbances as follows:

$$e = \sum_{j=1}^J w_j v_j \quad (40)$$

where  $w$  is a  $J$ -dimensional proper probability vector corresponding to a  $J$ -dimensional vector of weights  $v$ . These conversions then allow us to re-express the standard linear equations (38) as follows:

$$y = X\beta + e = XZp + Vw \quad (41)$$

with  $Z$  (respectively  $V$ ) is a matrix of support values for parameters (respectively disturbances) and  $p$  (respectively  $w$ ) the associated probability vector.

Using these conversions, it is possible to formulate the standard linear estimation problem as a GME problem:

$$\text{Max}_{p,w} H(p, w) = -p \ln p - w \ln w \quad (42)$$

subject to equations (41) and proper probability vectors.

Due to the form of the entropy function, it is not possible to derive an analytical solution to this optimisation program. Therefore, the maximum entropy distribution does not have a closed-form solution and numerical optimisation techniques must be used to compute the probabilities. As a result, parameter estimators do not have a closed-form solution as well. Nonetheless, the properties of these estimators have been established. For instance, Mittlehammer and Cardell (1997) have proved the consistency and the asymptotic normality of GME estimators in the general linear model. More

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<sup>100</sup> A proper probability vector is characterised by two properties:  $p_{km} \geq 0, \forall m = 1, \dots, M_k$  and  $\sum_{m=1}^{M_k} p_{km} = 1$ .

recently, Golan et al. (2000) have derived the properties of the GME estimators in the context of a nonlinear set of equations:  $y = f(X, \beta) + e$ . They find that if:

- i) the support space for the disturbances is a convex set that is symmetric around zero,
- ii) the support space for the parameters span the true values for each one of the parameters and have finite lower and upper bounds,
- iii) for each equation, the errors are independently and identically distributed with mean zero and with contemporaneous variance-covariance  $\Sigma$  of the vector of disturbances for the set of equations such that  $E[e, e'] = \Sigma \otimes I$ ,
- iv)  $p \lim (1/T)(\partial f / \partial \beta)'(\partial f / \partial \beta)$  exists and is non singular,

then, the GME estimators are consistent and asymptotically normal with:

$$\sqrt{T}(\hat{\beta} - \beta) \xrightarrow{d} N(0, \Omega)$$

$$\text{and } \Omega = p \lim (1/T)[(\partial f / \partial \beta)'(\Sigma^{-1} \otimes I)(\partial f / \partial \beta)]^{-1} \quad (43)$$

### 6.3.1.3. Discussion

The GME econometric technique is more and more widely used, particularly in the field of agricultural economics.<sup>101</sup> However, we must underline that the main difficulty when implementing the GME approach is the choice of support points for parameters as well as for disturbances. For example, if we intend to estimate a demand system with a large number of parameters, it is rather difficult to introduce appropriate support points for the parameters of the system, especially if prior information only exists on the sign and magnitude of elasticities which are complex functions of parameters and variables. In fact, the liberty given to the modeller, in terms of the choice of the support values, can be viewed as a virtue or a drawback of this approach, depending on the available prior information. If the modeller has a precise knowledge of the parameters' domain of variation, then this approach allows him to incorporate that information. On the other hand, if little or no such information on the plausible values of parameters do exist, then that liberty may reveal awkward.

This aspect has been dealt with in a large extent in the entropy literature. Many papers (for example GJM, 1996; Lence and Miller, 1998; Fraser, 1999) examine the sensitivity of GME estimators to the choice of support points for parameters as well as for disturbances. Three main results emerge from

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<sup>101</sup> Agricultural applications include Paris and Howitt (1998), Lence and Miller (1998), Heckelei and Britz (1999), Leon et al. (1999), Oude Lansink (1999), Oude Lansink et al. (2000), etc.

these sensitivity analyses. Firstly, changing the support points has little impact on the GME estimators, provided they contain the true values of the parameters. Secondly, for the case of general a priori ignorance about the parameters, it is suggested to distribute the support points over a large interval, i.e. between a large negative to a large positive bounds, since the larger the interval of the supports, the less the entropy criterion penalises deviations from a priori expectations. For the disturbances, the three sigma rule is recommended (cf Pukelsheim, 1994). Thirdly, whatever the support space including the true values of the parameters, GME estimators exhibit greater precision than other estimators.<sup>102</sup>

However, prediction powers of the GME estimators are generally lower than those of traditional estimators. That is to say, there is a trade-off between the prediction and the precision losses. GJM (1996) show that it is possible to increase the predictive capability of GME estimators by placing weights in the objective entropy function (42). This function includes entropies for both the parameter and disturbance distributions. As a result, the entropy objective reflects statistical losses in the sample space (prediction loss) and in the parameter space (precision loss). Depending on the problem at hand, we may wish to recover an image of the underlying system that reflects greater prediction and precision fidelity. As such, we may wish to place relatively more or less weight on the parameter and error components of the objective function in order to reflect the relative importance of these components.

The choice of the optimal weight in the objective function may be based on the normalised entropy criterion. This criterion, usually denoted  $S(p, w)$ , is given by:

$$S(p, w) = \frac{H(p, w)}{\sum_{k=1}^K \ln(M_k) + T \ln(J)} \quad (44)$$

It can be shown that this criterion equals the entropy of the distributions divided by the entropy of the uniform distribution and is comprised between zero and one. A value of zero reflects perfect knowledge or no uncertainty as regards to the value of the parameters and the disturbances. They are fully determined by the constraints. At the opposite, when the normalised entropy equals one, this indicates a state of full ignorance. The choice of the optimal weight, as well as the number and the levels of support points, can be made through the maximisation of this criterion.

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<sup>102</sup> Precision is generally measured in terms of mean squared error.

### 6.3.2. Implementation of the Generalised Maximum Entropy for the MECOP model

#### 6.3.2.1. The set of estimated equations

Our main objective with the GME approach is to estimate the parameters involved in the COP crop supply and land allocation functions previously described. In order to do so, we first add disturbances to these equations. These disturbances are noted  $ey_{i,t}$  for the supply functions and  $el_{i,t}$  for the land allocation functions. They capture specification errors, omitted variables, optimisation errors, etc. Secondly, it can be seen from equation (19) that the optimal output supply is a function of the normalised own price, time and the cultivated area. As this latter explanatory variable is endogenous, we introduce its expression in the supply function during the estimation stage. Therefore, the system of estimated equations is given by:

$$y_{i,t} = c_i + d_i \frac{p_{i,t}}{w_t} + f_i l_{i,t}(-) + h_i t + ey_{i,t} + f_i el_{i,t}, \forall i = 1, \dots, I; \forall t = 1, \dots, T$$

$$l_{i,t} = \frac{1}{e_i} \left[ \frac{\overline{L}_i + \sum_{j=1}^I \left( \frac{b_j + f_j \frac{p_{j,t}}{w_t} + g_j t}{e_j} \right)}{\sum_{j=1}^I 1/e_j} - b_i - f_i \frac{p_{i,t}}{w_t} - g_i t \right] + el_{i,t}, \forall i = 1, \dots, I; \forall t = 1, \dots, T1-1$$

$$l_{i,t} = \frac{1}{e_i} \left[ \frac{\overline{L}_i(1-\alpha_i) - \alpha_0 + \sum_{j=1}^I \left( \frac{b_j + f_j \frac{p_{j,t}}{w_t} + g_j t + \frac{a_{j,t}}{w_t}}{e_j} \right)}{\sum_{j=1}^I 1/e_j} - b_i - f_i \frac{p_{i,t}}{w_t} - g_i t - \frac{a_{i,t}}{w_t} \right] + el_{i,t}, \quad (45)$$

$$\forall i = 1, \dots, I; \forall t = T1, \dots, T$$

where  $T1$  corresponds to the year of implementation of the 1992 CAP reform.

All land derived demand and supply functions are estimated simultaneously using a GME technique. We directly estimate structural parameters and not reduced-form parameters. So doing, parameter restrictions are automatically satisfied. We do not omit one equation, as it is usually done with

traditional estimators, but add an additional constraint on land residuals. The sum over COP crops of these land residuals must equal zero. We furthermore add, during the estimation stage, the restrictions on land shadow prices (equations 26 and 28). Adding these inequality restrictions is quite easy with the GME estimation procedure. This mainly provides efficiency gains (Dorfman and McIntosh, 2001). On the other hand, it becomes much more difficult to define the distribution of the estimators and in particular to derive the variance of estimators. Testing can still be performed using the entropy-ratio statistic (see for example Golan et al, 1999). For example, if the purpose is to test the significance of one parameter, we need to re-estimate the model imposing the nullity of this parameter. Then, under the null hypothesis, two times the difference between entropy measures obtained from unconstrained and constrained models follows a Khi-deux distribution with one degree of freedom. The significance of all parameters involved in the MECOP model is tested using this procedure.

#### 6.3.2.2. *The choice of support values for parameters and disturbances*

In this point, we only describe how we have chosen the support values for parameters and disturbances. Their exact levels are reported in the following section.

For all parameters and disturbances, we retain three supports values, i.e.  $M_k = J = 3$ , as it has been demonstrated that the number of support values has no effects on estimates.<sup>103</sup> Furthermore, we assume that these support values are distributed symmetrically between the lower and upper bounds of the support spaces. Therefore, it remains to determine these bounds.

For the two kinds of disturbances, we adopt the three sigma rule advocated in many papers. So doing, we only need to compute the standard deviations of the endogenous variables for each EU Member State. Regarding the behavioural parameters, let start with  $f_i$ . From supply equations (19), we observe that this parameter measures the response of the supply of crop  $i$  to an increase in the area devoted to this crop, other things being equal:

$$f_i = \frac{\partial y_{i,t}}{\partial l_{i,t}} \quad (46)$$

We therefore suspect that its value lies around yield level. Hence, the bounds for this parameter are determined by the average yield more or less two standard deviations. For parameter  $d_i$ , the lower bound is given by the constraint (16) which ensures the convexity of profit functions with respect to

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<sup>103</sup> Obviously, two is the minimum.

prices. In addition, from the supply equation, it is also easy to show that this parameter is related to the price elasticity of output supply, for a given land allocation:

$$d_i = \frac{\partial y_{i,t}}{\partial (p_{i,t} / w_t)} \Big|_{l_{i,t}} = \varepsilon_{p_{i,t} / w_t | l_{i,t}}^{y_{i,t}} \frac{y_{i,t}}{(p_{i,t} / w_t)} \quad (47)$$

We assume that this elasticity is not greater than three and determine the upper bound of  $d_i$  accordingly.

For parameter  $e_i$ , we know from constraint (17) that it must be negative. Its upper bound is therefore zero. However, we have no other prior information for the lower bound of this parameter. We assume arbitrarily this lower bound at  $-1000$  for all products. In the same vein, we have no prior information for the bounds of other parameters:  $b_i, c_i, g_i, h_i$ . For all of them, we adopt large negative values for lower bounds ( $-1000$  and  $-10000$ ) and large positive values for upper bounds ( $1000$  and  $10000$ ).

#### 6.4. Estimation results

The MECOP model is designed at the national level. We apply the previously described framework to six EU Member States: France, United Kingdom, Germany, Italy, Spain and Denmark. We distinguish nine COP crops of which five cereals (soft wheat, barley, maize, oat and rye), three oilseeds (rape, sunflower and soya) and one protein crops (field peas). For oilseeds, we only consider food production. Each EU Member State produces only part of the nine COP crops. Hence, we distinguish seven crops for France, six for Germany and Italy, five for Spain and only three for the United Kingdom and Denmark (cf. Table 6.1). Therefore, in all six EU Member States, the supply and land allocations of other COP crops are considered as exogenous variables.

The six EU Member States realise most of the EU15 COP crop productions. Their respective contribution is provided in Table 6.2 for the year 1996/97. We can see that the six retained Member States together account for around 70% to 90% of the EU15 production for all considered COP crops, except for oats. This crop is primarily produced by the new Member States which have joined the EU in 1995 (Austria, Finland, Sweden).

In this section, we present and discuss estimation results for France only. Results for other Member States as well as elasticities computed for the year 1999 are reported in the appendix.

**Table 6.1. List of COP crops by EU Member State**

COP crops	France	United Kingdom	Germany	Italy	Spain	Denmark
Soft Wheat	+	+	+	+	+	+
Barley	+	+	+	+	+	+
Maize	+		+	+	+	
Oat			+	+	+	
Rye			+			
Rape	+	+	+			+
Sunflower	+			+	+	
Soya	+			+		
Field peas	+					

**Table 6.2. Production levels in 1996/97 (000 tonnes)**

COP crops	France	United Kingdom	Germany	Italy	Spain	Denmark	EU15	Share (%)
Soft Wheat	34330	15848	18973	3894	4212	4500	90229	90.6
Barley	9379	7857	12093	1406	10001	4166	52187	86.0
Maize	13776		2834	9087	3664		33707	87.1
Oats			1629	292	608		8062	38.2
Rye			4241				5728	74.0
Rape	2158	1188	1509			182	5736	87.8
Sunflower	1918			566	1221		3954	93.7
Soya				726			1018	71.3
Field peas	2593				89		3750	71.5

Source: European Commission. Situation and Outlook. Cereals, Oilseeds and Protein Crops. CAP 2000 Working Documents, DG Agriculture.

#### **6.4.1. Application to France**

From Table 6.3, it appears that, of the 49 behavioural parameters, 17 (respectively 22) parameter estimates are significant at the 0.05 (respectively 0.10) level of significance or better. We observe that no *b*<sub>i</sub> parameters are significant, even at a high level of significance. Only one *c*<sub>i</sub> parameter (for barley) is significant at the 10% level of significance. At this stage, it can be noted that these two structural parameters appear only in the constants of land and supply equations. The test of the significance of these constants shows that only two constants (for rape and sunflower) are statistically

significant. (cf. Table 6.4) . Only one  $d_i$  parameter (for rape) is statistically significant (cf. Table 6.3). That means that, in general, the price effects on production levels mainly occur through their effects on land uses. On the other hand, all  $e_i$  parameters are significant at the 0.05 level of significance, suggesting that profit functions are strictly concave in land allocations. All  $f_i$  parameters, but sunflower and soya, are significant at the 0.05 level of significance. Therefore, the land variable performs strongly as a determinant of production decisions. Finally, four  $g_i$  parameters and three  $h_i$  parameters are statistically significant at the 0.10 level of significance or better. These structural parameters capture the impacts of the trend on land uses and productions levels. The exact impacts of the trend on these variables as well as their level of significance are also reported in Table 6.4. We observe that the trend also performs strongly as a determinant of the evolution of production levels.

**Table 6.3. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft Wheat	759.470	-5569.183	26.364	-0.287**	4.390*	9.580*	537.123
Barley	487.498	-6780.083*	9.785	-0.321**	5.154*	-17.373	297.875**
Maize	487.288	-1168.663	0.504	-0.688**	5.877*	5.813	166.321**
Rape	-124.970	-3543.916	5.332†	-2.782**	2.633*	69.089**	121.285**
Sunflower	-440.149	-1900.276	3.081	-0.734**	2.043*	29.060*	57.620
Soya	-16.820	-65.50	0.128	-9.179**	1.523*	18.592	4.552
Field peas	-554.153	-2640.638	5.399	-23.875**	3.933	539.048**	90.153

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level.

**Table 6.4. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$
Soft Wheat	1170.62	-430.15	6.44	565.40**
Barley	199.37	-5752.54	-78.21**	-105.20**
Maize	92.71	-623.79	-2.79	149.94*
Rape	-197.15**	-4063.01*	22.06	179.36**
Sunflower	-1176.63**	-4304.14**	29.06	116.99**
Soya	-47.97	-138.56	1.18	6.35
Field peas	-40.95**	-2801.69	22.25**	177.68**

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level.

Next, we test for residual first-order autocorrelation using the generalisation detailed in Moschini and Moro (1994). Basically, these authors propose a new parametric specification of the autocorrelation matrix for singular equation systems that satisfies the restrictions of adding-up and that entails only as many parameters as the number of equations. Accordingly, we test the residual first-order autocorrelation with different autocorrelation coefficients for each land equation and for each supply equation. We also perform additional tests using the same autocorrelation coefficient for all land equations. These nested tests fail to reject the absence of serial correlation. We also test for structural changes of behavioural parameters and do not find statistically significant structural changes.

The normalised entropy measures are quite high. They are 0.720 for the parameters, 0.977 for the disturbances and 0.946 for the system as a whole. From the fact that they are smaller than one, it can be inferred that data on production and land allocation contain some information and that this information has been used to determine the values of behavioural parameters. We also report in Table 6.5 correlation coefficients between observed and estimated series. In a general way, these figures suggest that the estimated model fits the data reasonably well.

**Table 6.5. Correlation coefficient between observed and estimated series**

COP crops	Land equations	Supply equations
Soft Wheat	0.806	0.932
Barley	0.919	0.711
Maize	0.528	0.915
Rape	0.853	0.895
Sunflower	0.907	0.909
Soya	0.896	0.899
Field peas	0.898	0.790

Tables 6.6 and 6.7 report the elasticities of cultivated areas with respect to, respectively, prices and area payments, computed for the year 1999.

**Table 6.6. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Rape	Sunflower	Soya	Field peas
Soft Wheat	0.233	-0.125	-0.073	-0.015	-0.048	-0.002	-0.002
Barley	-0.426	0.922	-0.248	-0.052	-0.162	-0.007	-0.006
Maize	-0.141	-0.139	0.476	-0.017	-0.053	-0.002	-0.002
Rape	-0.074	-0.073	-0.043	0.240	-0.028	-0.001	-0.001
Sunflower	-0.212	-0.210	-0.123	-0.026	0.508	-0.004	-0.003
Soya	-0.229	-0.226	-0.133	-0.028	-0.087	0.362	-0.003
Field peas	-0.012	-0.012	-0.007	-0.001	-0.004	-0.002	0.040

**Table 6.7. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Rape	Sunflower	Soya	Field peas
Soft Wheat	0.151	-0.073	-0.039	-0.012	-0.046	-0.004	-0.001
Barley	-0.277	0.541	-0.132	-0.041	-0.156	-0.013	-0.005
Maize	-0.091	-0.082	0.253	-0.014	-0.052	-0.004	-0.002
Rape	-0.048	-0.043	-0.023	0.190	-0.027	-0.002	-0.001
Sunflower	-0.138	-0.123	-0.066	-0.021	0.489	-0.006	-0.002
Soya	-0.149	-0.133	-0.071	-0.022	-0.084	0.605	-0.002
Field peas	-0.008	-0.007	-0.004	-0.001	-0.004	-0.003	0.029

In a general way, we observe that cereal areas are more price responsive to their own price than oilseed and almost protein crop areas. For instance, barley areas exhibit the greatest own price elasticity (+0.922) and field peas the lowest one (+0.040). It is interesting to note that all cereal prices have significant effects on cereal areas and low effects on oilseed and protein crop areas. In the same way, oilseed prices mainly influence oilseed areas and have low impacts on cereal areas. Among the group of cereal crops, it appears that soft wheat and barley are strong substitutes in the competition for land. Finally, all these price elasticities are lower than one in absolute values.

Direct payment elasticities of cultivated areas have smaller absolute values than their corresponding price elasticities. We finally observe that own direct payment effects are in average greater for oilseed areas than for cereal areas. Again, effects of direct payments on field peas area are nearly null.

Tables 6.8 and 6.9 report the elasticities of output supplies with respect to, respectively, prices and area payments, computed for the year 1999. Table 6.8 shows that supply functions of the seven COP crops are upward sloping in their own price and respond negatively to cross prices. They are all inelastic, with barley the most elastic (0.796) and field peas and soft wheat the less elastic ones (0.298 and 0.237, respectively). According to supply functions (19), own price supply elasticities may be decomposed into a direct effect and an indirect effect due to the reallocation of land between the COP crops. Direct effects may be evaluated from COP crop specific supply functions where land allocation is fixed. They are reported in brackets in Table 6.8. One verifies that these direct effects are lower than the total effects, which reflects the "Le Chatelier-Samuelson" principle. These direct effects are rather low, except for rape, sunflower and field peas. For rape and field peas, the direct effect accounts for around, respectively, 70% and 90% of the total effect. For cross price elasticities, the direct effect equals zero by assumption since the "fixed allocation" technology is non-joint in variable inputs. These cross price elasticities are much lower, in absolute values, than own price elasticities of COP crop supplies. That certainly does not mean that they have no impacts on production levels.

Table 6.9 shows that COP crop supply functions are upward sloping in own direct payments and respond negatively to cross direct payments.

**Table 6.8. Estimates of price elasticities of COP crop supplies (year 1999; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Maize	Rape	Sunflower	Soya	Field peas
Soft Wheat	0.237 [0.089]	-0.079	-0.046	-0.010	-0.030	-0.001	-0.001
Barley	-0.314	0.796 [0.117]	-0.182	-0.038	-0.120	-0.006	-0.005
Maize	-0.106	-0.105	0.362 [0.004]	-0.013	-0.040	-0.002	-0.002
Rape	-0.052	-0.052	-0.030	0.548 [0.378]	-0.020	-0.001	-0.001
Sunflower	-0.182	-0.180	-0.106	-0.022	0.710 [0.274]	-0.003	-0.003
Soya	-0.139	-0.137	-0.080	-0.017	-0.053	0.331 [0.112]	-0.002
Field peas	-0.009	-0.009	-0.005	-0.001	-0.004	-0.001	0.298 [0.266]

**Table 6.9. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Maize	Rape	Sunflower	Soya	Field peas
Soft Wheat	0.096	-0.046	-0.025	-0.008	-0.029	-0.002	-0.001
Barley	-0.204	-0.399	-0.097	-0.030	-0.115	-0.009	-0.003
Maize	-0.069	-0.062	0.191	-0.010	-0.039	-0.003	-0.001
Rape	-0.034	-0.030	-0.016	0.135	-0.019	-0.002	-0.001
Sunflower	-0.118	-0.106	-0.056	-0.018	0.420	-0.005	-0.002
Soya	-0.090	-0.081	-0.043	-0.013	-0.051	0.366	-0.001
Field peas	-0.006	-0.005	-0.003	-0.001	-0.003	-0.001	0.021

Table 6.10 reports the elasticities of cultivated areas and output supplies with respect to total available land and the variable input price.

**Table 6.10. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\epsilon_L^i$	$\epsilon_L^y$	$\epsilon_w^i$	$\epsilon_w^y$
Soft Wheat	0.769 [0.351]	0.488	0.056	-0.054
Barley	2.607 [0.314]	1.922	0.062	-0.071
Maize	0.859 [0.146]	0.647	-0.131	-0.103
Rape	0.451 [0.036]	0.321	-0.066	-0.424
Sunflower	1.297 [0.137]	1.115	-0.063	-0.328
Soya	1.399 [0.004]	0.847	0.201	0.010
Field peas	0.071 [0.012]	0.057	-0.009	-0.273

From the first column of Table 6.10, we observe that the elasticities of barley, sunflower and soya areas with respect to total land are greater than one, while these elasticities are lower than one for the other crops. Terms in brackets in the first column of Table 6.10 measure the change in cultivated areas

of each crop due to an increase of one unit of total land for cropping. An additional hectare of land for cultivation would increase allocation to soft wheat by 0.351, to barley by 0.314, to maize by 0.146 and to sunflower by 0.137. The corresponding response for other COP crops are much lower. Table 6.10 also provides the elasticities of areas and output supplies with respect to the aggregate variable input price. As expected, an increase in the variable input price would lead to a decrease in COP production, except for soya. The effects of this price on land allocations may be positive or negative, depending on the considered COP crop. Therefore, the aggregate variable input and land may be substitute or complements in COP crop production technologies.

## **6.5. Policy simulations: The Agenda 2000 CAP reform and beyond**

### **6.5.1. Background and motivation**

In a general way, the Agenda 2000 CAP reform deepens the 1992 or MacSharry CAP reform, with new cuts in support prices compensated by new or increased direct payments. As far as the COP sector is concerned, the complete application of this new reform in 2002 will mainly involve a 15% reduction in cereal intervention prices, an increase of direct payments for cereal areas from 54 Euro/tonne to 63 Euro/tonne, a reduction of direct payments for oilseed areas from 94.24 Euro/tonne to 63 Euro/tonne and a reduction of direct payments for pulses from 78.5 Euro/tonne to 72.5 Euro/tonne. Moreover, the direct payments for set aside areas are also reduced from 68 Euro/tonne to 63 Euro/tonne. Finally, the mandatory set-aside rate is fixed to 10%, but the European commission (EC) might revise this rate according to the evolution of market conditions. Therefore, with the Agenda 2000 reform, the Common Market Organisation (CMO) for arable crops moves towards a standardisation across COP crops of area direct payments.

Quantitative analyses of the likely impacts on markets of this new reform are obviously numerous. Most often, they conclude that, despite the induced decrease in the domestic market prices of cereals, the full implementation of this reform would expand cereal areas as compared to a status quo scenario. Table 6.11 suggests that only the OECD projects a slight decrease in cereal areas. All modelling exercises also concede that their results are sensitive to the evolution of both the world market conditions and the exchange rate between the Euro and the US dollar. On the other hand, the likely impact of the Agenda 2000 CAP reform on oilseed areas is more discussed. Both FAPRI institutes, the OECD and the University of Amsterdam forecast a decrease, the University of Bonn projects a stagnation and finally the USDA-ERS expects an increase of the oilseed areas compared to a no-reform baseline (cf. Table 6.11).

**Table 6.11. Percentage changes in cultivated areas between Agenda 2000 and baseline scenarios (year 2005) according to various published studies**

Area	SPEL (Bonn)	FAPRI (Missouri)	FAPRI (Iowa)	CAPMAT (Amsterdam)	USDA	OECD
<u>Wheat</u>	+2.6	+4.0	+5.9	+2.6	+6.4	-1
Soft wheat	+2.5	n.a.	n.a.	+2.8	n.a.	n.a.
Durum wheat	+3.4	n.a.	n.a.	+1.4	n.a.	n.a.
<u>Coarse grains</u>	+2.2	n.a.	n.a.	-0.6	+4.5	-1
Barley	+2.2	+2.6	+5.0	-0.5	n.a.	n.a.
Maize	+4.6	+0.8	+3.5	-1.4	n.a.	n.a.
<u>Oilseeds</u>	-0.3	-2.8	n.a.	-2.9	+6.1	-5
Rape	-3.2	-2.6	-4.8	-4.0	n.a.	n.a.
Sunflower	+2.4	-3.1	n.a.	-1.9	n.a.	n.a.
Soya	+4.0	-3.1	-0.5	-2.5	n.a.	n.a.

Table 6.11 suggests that if some results are qualitatively identical in nearly all reported studies, such as the increase in cereal areas, the huge difference observed between figures is striking. Such differences are not so surprising since used models differ in terms of specifications, data sources, calibration process, etc. Moreover, different baseline assumptions contribute to this heterogeneity across results.

Nevertheless, the magnitude of these differences is worthy to note. Let's consider obtained results for wheat (including soft and durum wheat) in more details. Table 6.12 reports the forecasts performed by six institutes for the campaign 2004/05. In this table, the absolute levels of the projected variables are provided, as well as their observed levels for the campaign 1998/99. While forecasts are often analysed in comparison of a baseline scenario in order to highlight the impacts of policy instruments, we compare here these forecasts to observed initial figures in order to avoid the arbitrary nature of the baseline scenarios. From the third column of Table 6.12, we observe that the expected adjustment in wheat area between the campaigns 2004/05 and 1998/99 ranges between stagnation (- 0.06% for FAPRI-IOWA) to a strong increase (+ 8.77% for OECD). In absolute levels, the expected wheat area for 2004/05 varies between 16.74 (FAPRI-IOWA) to 18.6 (OECD) millions hectares, representing a 1.86 million hectares gap or 11.11% of the lower estimates. In terms of production, differences are also considerable. According to FAPRI-IOWA (respectively OECD), wheat production would decrease by 1.49% (respectively increase by 9.40%) by the campaign 2004/05 relative to the campaign 1998/99. In absolute levels, the estimated wheat production for 2004/05 varies between 102.1 (FAPRI-IOWA) and 111.70 (OECD) millions tons, representing a 10.64 millions tonnes gap or 10.52% of the lower estimates. Finally, regarding yields, differences between results published by the various

institutes are also substantial even if less important than those noticed for cultivated area and production.

**Table 6.12. Wheat forecasts according to different institutes (percentage changes from the observed campaign 1998/99 in parentheses)**

Institutes (Model)	Campaign	Area (millions ha)	Yield (tonne/ha)	Production (mio. tonnes)	Market prices (Euro/tonne)	Set aside rate (%)
FAPRI-UMC (GOLD)	1998/99	17.046	6.07	103.478	126.0	5%
	2004/05	17.423	6.18	107.610	124.0	5%
		(+2.21%)	(+1.81%)	(+3.99%)	(-1.60%)	(0%)
FAPRI-IOWA (FAPRI)	1998/99	16.75	6.12	102.59	120.0	5%
	2004/05	16.74	6.04	101.06	112.7	10%
		(-0.06%)	(-1.31%)	(-1.49%)	(-6.02%)	(+100%)
European Commission	1998/99	17.10	5.99	102.4	n. a.	5%
	2004/05	18.20	6.03	109.7	n. a.	10%
		(+6.43%)	(+0.67%)	(+7.12%)		(+100%)
USDA-ERS (ESIM)	1998	17.065	6.07	103.536	n. a.	5%
	2005	17.246	6.27	108.219	n. a.	10%
		(+1.05%)	(+3.29%)	(+4.52%)		(+100%)
OECD (AGLINK)	1998/99	17.1	5.98	102.1	120	5%
	2004/05	18.6	6.00	111.7	114	15.5%
		(+8.77%)	(+0.33%)	(+9.40%)	(-5%)	(+210%)
ONIC (MONIC)	1998/99	17.120	6.00	102.775	n. a.	5%
	2004/05	17.335	6.30	109.261	n. a.	10%
		(+1.25%)	(+5%)	(+6.31%)		(+100%)

Attempts to explain these differences have mainly focused on the assumptions regarding the evolution of domestic market prices as well as the mandatory set-aside rate, in the baseline scenario and in the Agenda 2000 scenario. The evolution of these explanatory variables adopted by the different institutes in their Agenda 2000 scenarios are provided in the last columns of Table 6.12. These evolutions are obviously divergent and may partly explained the observed differences in simulated endogenous variables. However, it is still difficult to draw a clear picture of the specific impact of each policy instrument (intervention prices, mandatory set-aside rate and area payments) on quantity variables. Furthermore, the likely impacts of direct payments on the results and by extension on these differences have never been underlined by these studies. More generally, the likely impacts of the Agenda 2000 area direct payment package have been only occasionally analysed (Salvatici et al., 2000). As an exception, Gohin et al. (2000) examine, using a Computable General Equilibrium (CGE) model focused on the French agro-food complex, the sensitivity of results of Agenda 2000 experiments to the modelling of area direct payments. They find that domestic production of soft wheat may increase by 6% or decrease by 8% relative to the base period, depending on the adopted modelling of these direct payments. Therefore, these figures suggest that sorting out the impacts of direct payments on results is

clearly valuable. From a policy perspective, understanding and assessing the contribution of the standardisation of direct payments is also relevant. The 1992 CAP reform introduced differentiated area direct payments favouring oilseed crops. This was motivated by the willingness to develop the production of oilseed crops and then to reduce the European dependence on imports. This relative advantage given to oilseed crops has however been severely criticised by third countries during the Uruguay Round negotiations, leading to the Blair House agreement and some restrictions on the European oilseed sector. The alignment of direct payments for oilseed areas to those for cereal areas, decided in the Agenda 2000 CAP reform, will make irrelevant these restrictions but it is likely that this will be to the detriment of the European oilseed production. Gauging the impacts of the direct payment standardisation is therefore of great interest.

In that context, the purposes of the scenarios performed below with the MECOP model are twofold. The first one is to isolate the effects of the changes in direct payments on the evolution of areas, per hectare yields and productions from the effects of other policy instruments. We also provide the impacts of our scenarios on the evolution of macro-variables such as the unit land return, public expenditures on direct payments and profits. The second one is to examine the sensitivity of our results to the evolution of market prices and set-aside rates, as there are still great uncertainties in that respect.

#### ***6.5.2. Definition of simulated scenarios***

We first perform a baseline scenario and next three Agenda 2000 scenarios that differ in terms of the assumed evolution of market prices and set-aside rates. For all scenarios, results are computed for the campaign 2004/05, when the Agenda 2000 CAP reform is completely implemented.

In all scenarios, we assume that the total land available for cropping is equal to the level observed during a specific campaign<sup>104</sup>, unless the unit land return becomes lower than the set-aside direct payment. In this special case, the total available land for cropping is adjusted for the land return to be equal to the set-aside direct payment.

In our baseline scenario, we maintain output market prices and area direct payments at their 1998/99 level. The price of variable inputs is increased by 1% per year. We assume that the mandatory set-aside rate is 12%.

In our three Agenda 2000 scenarios, area direct payments are adjusted according to the provisions of the Agenda 2000 CAP reform. Hence, we perform an increase in cereal area direct payments and a

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<sup>104</sup> This campaign corresponds to 1996/97 in both the baseline and the central Agenda 2000 scenarios. While the retained campaigns are 1995/96 and 1998/99 in, respectively, the pessimist and the optimist variants of the Agenda 2000 scenario (cf. Table 6.13).

reduction in oilseed area direct payments as well as in the set-aside direct payment, which are both align to those granted to cereals (cf. Table 6.13.). Finally, we set the direct payment for protein areas at the level decided in the Agenda 2000 reform.

Then, the three Agenda 2000 scenarios differ in the assumed evolution of market prices and of the set-aside rate. In the central scenario, we assume that the EU market price of soft wheat decreases by only 10%, while the decrease in the market prices of other cereals follows the 15% reduction in the intervention prices. The market prices of oilseeds and protein crops are assumed to remain constant (in nominal terms) at their initial level. Regarding the variable input prices, we keep the assumption of a 1% increase per year. Finally, we assume that the mandatory set-aside rate is 10%.

In the first variant, labelled the pessimist scenario, we assume that the evolution of world market conditions and/or the evolution of the exchange rate are unfavourable to the EU arable crop sector. Soft wheat market price now decreases by 15%, prices of oilseeds and protein crops by 5% and variable input prices increase by 2% per year. This unfavourable context also requires a greater effort in terms of supply control, so that the mandatory set-aside rate is set at 15%.

Finally, the last experiment, labelled the optimist scenario, assumes favourable world market developments and/or exchange rate evolution from the EU COP sector perspective. The EU market price of soft wheat is assumed to remain constant while the EU market prices of other cereals are assumed to decrease by only 5%. Market prices of oilseeds and protein crops now increase by 5% while the variable input price remains constant. Finally, the mandatory set-aside rate is set at 5%.

**Table 6.13. Adopted assumptions in the Agenda 2000 scenarios**

	Pessimist scenario	Central scenario	Optimist scenario
<i>Changes in market prices w.r.t. 1998/99 levels</i>			
Soft wheat	-15%	-10%	0%
Other cereals	-15%	-15%	-5%
Oilseeds	-5%	0%	+5%
Protein crops	-5%	0%	+5%
Variable inputs	+2% per year	+1% per year	0%
<i>Mandatory set-aside rate</i> i.e. total available land for cropping given by the campaign			
	15% 1994/95	10% 1996/97	5% 1998/99
<i>Levels of area direct payments</i>			
Cereals	63 Euro/ton		
Oilseeds	63 Euro/ton		
Protein crops	72.5 Euro/ton		
Set-aside	63 Euro/ton		

**6.5.3. The likely impacts of the Agenda 2000 CAP reform: The central scenario**

We discuss the impacts of the central scenario in comparison first with the 1998/99 campaign and next with the baseline scenario. Table 6.14 presents the results of both the baseline and the central scenarios in terms of land allocation, productions, yields and unit land return at the EU6 level for 2004/05. The corresponding levels of these variables in the 1998/99 base year are also reported in the first column of Table 6.14.

The Agenda 2000 central scenario leads to strong effects on the European arable crop sector. As an example, production of soft wheat would increase by 7.17%, i.e. nearly 6 millions tonnes, while oat production would decrease by 5.14% with respect to the 1998/99 base year. Regarding land allocation, let's first remind that total land devoted to COP production decreases (by 1527 thousand hectares) due to the increase in the mandatory set aside. All COP enterprises experience a decrease in cultivated area. The most affected COP crops are soya, sunflower and rye as far as percentage changes are concerned, and barley, soft wheat and sunflower when dealing with absolute levels. While the simulated changes in cultivated areas and production quantities differ greatly across COP crops, we observe less marked differences as regards to yield impacts. The yields of the "main" COP crops increase within the range of 9 - 15%, corresponding to a 1.5 to 2.5% increase in the average annual

yield growth. Finally, the impact of our Agenda 2000 central scenario on the unit land return is negative (-6.44% or -22 Euro/ha).

Our results on soft wheat depart significantly from those obtained by other studies reported in Table 6.12. From 1998/99 to 2004/05, soft wheat yield is expected to increase by 9.76% according to our analysis, by 5% according to MONIC and to decrease by 1.31% according to FAPRI-IOWA. Land allocated to soft wheat decreases slightly (-2.36% or 299 thousand hectares) in our central scenario, so that our estimate is below the estimates found in the literature (cf. Table 6.12). Nevertheless, we forecast a 7.17% increase in soft wheat production with respect to the 1998/99 level, which is in the range of estimates obtained by other studies (except FAPRI-IOWA which forecasts a -1.49% decrease).

The results described above capture not only the impact of the Agenda 2000 CAP reform but also the trend effects. In order to isolate the impacts of the reform, we now compare the results of the central scenario to the results of the baseline scenario. This comparison is reported in the last column of Table 6.14. As expected, the application of the Agenda 2000 CAP reform is likely to increase areas devoted to cereals (except oat) and decrease areas devoted to oilseeds. The impact of the reform on the protein crop area is slightly positive. Our expected +3.28% increase in the cereal total cultivated area corresponds roughly to the middle range of estimates published by other studies (cf. Table 6.11). However, our expected impact of the Agenda 2000 reform on the area devoted to oilseeds is more pessimistic than other available estimates. Nevertheless, like existing studies, we also find that rape (-1.58%) would be less affected than sunflower (-3.95%) and much more less affected than soya (-20.24%). On the other hand, the application of the Agenda 2000 CAP reform would lead to a decrease in cereal yields and an increase in oilseed yields. These impacts on yields would not outweigh those on cultivated areas previously described, so that the effects of the reform on the produced quantities are less pronounced than its impacts on land uses. In particular, cereal production would increase by 0.97%, oilseed production would decrease by 2.79% and field peas production would increase by 0.40%. Finally, the impact of the reform on the unit land return is negative (-13.33% or -48 Euro/ha).

**Table 6.14. Impacts of the baseline and of the central Agenda 2000 scenarios on the EU6 arable crop sector: land allocation, output supplies, yields and land return**

	Base levels 1998/99 (I)	Central scenario (2004/05) (II)	Change in % (II)-(I)	Baseline (2004/05) (III)	Change in % (II)-(III)
<b>Land allocation</b>	<b>(1000 hectares)</b>				
Soft wheat	12648	12349	-2.36	11883	+3.92
Barley	9707	9234	-4.87	8951	+3.16
Maize	3574	3422	-4.26	3362	+1.78
Oat	687	632	-8.05	633	-0.16
Rye	834	736	-11.69	706	+4.25
All cereals	27450	26373	-3.92	25535	+3.28
Rape	2169	2052	-5.40	2085	-1.58
Sunflower	2333	2093	-10.28	2179	-3.95
Soya	355	264	-25.57	331	-20.24
All oilseeds	4857	4409	-9.22	4595	-4.05
Field peas	589	587	-0.36	584	+0.51
All COP crops	32896	31369	-4.64	30714	+2.13
<b>Production</b>	<b>(1000 tonnes)</b>				
Soft wheat	79703	85419	+7.17	84038	+1.64
Barley	43173	45225	+4.75	44971	+0.56
Maize	29662	31856	+7.40	31662	+0.61
Oat	2004	1901	-5.14	2184	-12.96
Rye	4225	4235	+0.23	4156	+1.90
All cereals	158767	168636	+6.22	167011	+0.97
Rape	6881	7725	+12.26	7802	-0.98
Sunflower	3921	4135	+5.47	4220	-2.01
Soya	1274	1414	+10.96	1633	-13.41
All oilseeds	12076	13274	+9.92	13655	-2.79
Field peas	2797	3285	+17.43	3272	+0.40
<b>Yields</b>	<b>(tonnes/ha)</b>				
Soft wheat	6.301	6.916	+9.76	7.071	-2.19
Barley	4.448	4.898	+10.12	5.024	-2.51
Maize	8.299	9.310	+12.18	9.417	-1.14
Oat	2.917	3.009	+3.16	3.450	-12.78
Rye	5.065	5.749	+13.50	5.884	-2.29
Rape	3.172	3.764	+18.67	3.741	+0.61
Sunflower	1.680	1.975	+17.55	1.936	+2.01
Soya	3.589	5.351	+49.08	4.939	+8.34
Field peas	4.750	5.598	+17.85	5.607	-0.16
Land return (Euro/ha)	334	312	-6.44	360	-13.33

A decomposition of these impacts into the respective effects of market prices, direct payments and total available land is clearly relevant to understand these evolutions. That decomposition is also valuable from a policy perspective for clarifying the specific impact of each policy instrument, in particular the impact of the area direct payment package of the reform on land uses, yields and productions. Due to the linearity of the endogenous variables of the MECOP model with respect to exogenous variables, such a decomposition is straightforward. It is provided in Table 6.15.

The increase in total land available for COP production affects positively the cultivated areas of all COP crops, except soya. In physical terms, the greatest increases are observed for barley (+247 thousand hectares) and soft wheat (+207 thousand hectares), while oilseed areas are only slightly affected (+94 thousand hectares as a whole). The increase in total COP land has a negative impact on cereal and field peas yields and affects positively oilseed yields. However, these effects are quite modest, so that the total impact of the total land increase on production is similar to its impact on land uses. In physical terms, the most important impacts are once again observed for barley (+1286 thousand tonnes) and soft wheat (+1085 thousand tonnes). From a political point of view, these outcomes illustrate the differentiated impacts of the set-aside policy on COP areas and productions, which acts mainly to the detriment of cereal areas and productions. This suggests that the set-aside policy is an effective mechanism to control cereal productions while slightly affecting oilseed productions. Finally, the increase in total cultivated land reduces the competition among COP enterprises for this scarce primary factor of production and therefore leads to a decrease in the unit land return.

As expected, the whole effect of the area direct payment changes is an increase in cereal areas and a decrease in oilseed and protein crop areas. For example, soft wheat area increases by 185 thousand hectares while rape area decreases by 118 thousand hectares due to the changes in area direct payments. The most affected COP crop is sunflower with a reduction of 300 thousand hectares. Field peas area always receives a higher payment but this does not prevent a one thousand hectare decrease in the cultivated area of this crop. The impacts of changes in area direct payments on yields differ across COP crops. It is negative for cereals and positive for other COP crops. Once again, one may observe that the impact of the Agenda 2000 area direct payment package on yields is quite limited. Concerning COP production, the impacts on land uses dominate the impacts on yields, so that cereal productions increase while oilseed and protein crop productions decrease. The alignment of oilseed direct payments to cereal direct payments would reduce soya production by 258 thousand tons, rape production by 290 thousand tons and sunflower production by 426 thousand tons. Finally, this direct payment package would increase the unit land return by 23 Euro/ha, suggesting that the positive impact of increased cereal area direct payments overcomes the negative impact of reduced oilseed area previous differentiated area direct payments on EU production of oilseeds. direct payments. From a political point of view, these outcomes confirm the positive impacts of the

**Table 6.15. Decomposition of the total impacts of the central Agenda 2000 scenario on the EU6 arable sector: price, direct payment and set-aside effects**

	Difference between the central and baseline scenarios	Price effects	Direct payment effects	Set aside effects
<b>Land allocation</b>	<b>(1000 hectares)</b>			
Soft wheat	+466	+74	+185	+207
Barley	+283	-206	+242	+247
Maize	+60	-80	+67	+73
Oat	-1	-19	+6	+12
Rye	+30	+7	+3	+20
All cereals	+838	-224	+503	+559
Rape	-33	+56	-118	+29
Sunflower	-86	+142	-300	+72
Soya	-67	+24	-84	-7
All oilseeds	-186	+222	-502	+94
Field peas	+3	+2	-1	+2
All COP crops	+655	0	0	+655
<b>Production</b>	<b>(1000 tonnes)</b>			
Soft wheat	+1381	-414	+710	+1085
Barley	+254	-1924	+892	+1286
Maize	+194	-607	+379	+422
Oat	-283	-343	+14	+46
Rye	+79	-8	+11	+76
All cereals	+1625	-3296	+2006	+2915
Rape	-77	+136	-290	+77
Sunflower	-85	+196	-426	+145
Soya	-219	+69	-258	-30
All oilseeds	-381	+401	-974	+192
Field peas	+13	+9	-5	+9
<b>Yields</b>	<b>(tonnes/ha)</b>			<b>(Obtained by difference)</b>
Soft wheat	-0.155	-0.069	-0.036	-0.050
Barley	-0.126	-0.104	-0.018	-0.004
Maize	-0.107	+0.017	-0.049	-0.075
Oat	-0.441	-0.420	-0.007	-0.014
Rye	-0.135	-0.064	-0.005	-0.066
Rape	+0.023	-0.018	+0.039	+0.002
Sunflower	+0.039	-0.018	+0.037	+0.020
Soya	+0.412	-0.047	+0.126	+0.333
Field peas	-0.009	-0.003	+0.020	-0.008
Land return (Euro/ha)	-49	-49	+23	-23

The reduction in cereal market prices contributes to increase cultivated areas devoted to oilseeds (+222 thousand hectares) and protein crops (2 thousand hectares). On the other hand, these market price reductions have a negative impact on the cereal area (-224 thousand hectares). However, the negative own price effects are compensated by the positive cross price effects in the case of soft wheat and rye. One may observe that all yields, but maize, decrease as a result of the reduction in cereal market prices. Yield adjustments dominate land adjustments in the case of soft wheat and rye, so that the market price changes lead to a decrease in their productions. Similarly, productions of other cereals decrease following the market price changes. At reverse, productions of oilseeds and protein crops increase. As expected, the reduction in cereal market prices has a negative impact on the unit land return.

Finally, it is interesting to compare the respective impacts of the three kinds of instruments. We first observe that the positive impact on the unit land return of the direct payment package is lower, in absolute value, than the negative impact of the price package. This situation is quite different from the one corresponding to the 1992 CAP reform where area direct payments had been determined in order to exactly compensate the price decrease effects on per hectare revenue. The negative price effects also dominate the positive direct payment effects on cereal productions (-3296 versus +2006 thousand tons). Therefore, the positive effect of the Agenda 2000 CAP reform on cereal productions mainly results from the reduction in the set-aside rate. On the contrary, the positive effects on oilseed production resulting from both the reduction in cereal prices (+401 thousand hectares) and the reduction in the set-aside rate (+192 thousand hectares) are not sufficient to compensate for the negative effects resulting from the direct payment package of the reform (-974 thousand hectares).

We finally examine the impacts of the baseline and the central scenarios on macro-economic variables. The impacts of both scenarios on public expenditures in the guise of area direct payments are reported in Table 6.16. Their effects in terms of profits for each COP enterprise are presented in Table 6.17.

The application of the central scenario leads to an increase in public expenditures in the guise of area direct payments, compared to the base level. This increase amounts to 581 millions Euro or 5.20% of our base year estimate of area payment expenditures. Obviously, direct payments granted to cereal areas increase (by more than 10% for cereals considered as a whole), while those granted to oilseed areas decrease (by 33.55%) with respect to the base year. Public expenditures on set-aside areas also increase due to the increase in these areas that compensate for a lower per hectare direct payment.

Compared to the no-reform or baseline scenario, the central scenario still induces an increase in public expenditures. The extra-budgetary cost of the central scenario over the baseline scenario amounts to 457 millions Euro or 4.05% of the baseline simulated total area payment expenditures.

**Table 6.16. Impacts of the baseline and of the central Agenda 2000 scenarios on public expenditures**

	Base levels 1998/99 (I)	Central scenario (2004/05) (II)	Change in % (II)-(I)	Baseline (2004/05) (III)	Change in % (II)-(III)
Direct payments	(mio. Euro)				
Soft wheat	3674	4152	+13.00	3433	+20.94
Barley	2325	2521	+8.43	2085	+20.91
Maize	1316	1461	+11.02	1238	+18.01
Oat	149	153	+2.52	133	+15.04
Rye	249	255	+2.44	211	+20.85
All cereals	7713	8541	+10.74	7100	+20.29
Rape	1045	743	-28.94	1005	-26.07
Sunflower	831	539	-35.12	754	-28.51
Soya	164	74	-55.01	155	-52.25
All oilseeds	2040	1356	-33.55	1911	-29.04
Field peas	263	256	-2.69	261	-1.91
All COP crops	10017	10154	+1.37	9272	+9.51
Set aside	1151	1595	+38.58	2020	-21.04
Arable crop CMO	11168	11749	+5.20	11292	+4.05

The implementation of the Agenda 2000 CAP reform leads to an increase in the total profit of arable crop farmers compared to the base level (1486 millions Euro). However, land remuneration decreases in line with previous findings on the unit land return. On the other hand, reward of the other primary factors of production increases by 2228 millions Euro with respect to the base level.

Finally, compared to a no-reform scenario, our central Agenda 2000 scenario leads to a decrease in total farm profits (-636 millions Euro), with again a reduction in the land remuneration and a more modest increase in the remuneration of the other primary factors.

**Table 6.17. Impacts of the baseline and of the central Agenda 2000 scenarios on profits of COP enterprises**

Millions Euro	Effects of the central scenario compared to base levels (1998/99)			Effects of the central scenario compared to the baseline scenario		
	Total profit	Land remuneration	Other factors remuneration	Total profit	Land remuneration	Other factors remuneration
Soft wheat	+494	-338	+833	-86	-532	+446
Barley	+114	-397	+511	+242	-237	+479
Maize	+172	-133	+305	-39	-140	+101
Oat	-17	-34	+17	+10	-17	+27
Rye	+8	-35	+43	-3	-12	+9
All cereals	+771	-937	+1708	+124	-938	+1062
Rape	+181	-68	+248	-153	-142	-11
Sunflower	+3	-140	+142	-108	-113	+5
Soya	+9	-31	+40	-65	-22	-43
All oilseeds	+193	-238	+431	-326	-277	-49
Field peas	+79	-11	+89	-49	-49	0
All COP crops	+1042	-1186	+2228	-251	-1264	+1013
Set aside	+444	+444	0	-385	-385	0
All activities	+1486	-742	+2228	-636	-1649	+1013

**6.5.4. Sensivity analysis: The sensivity of the Agenda 2000 simulation results to the assumed evolution of market prices and the set-aside rate**

The likely impacts of the Agenda 2000 reform on the EU COP sector reported in all existing studies, including the present one, clearly depend on the retained assumptions regarding the evolution of COP crop market prices as well as of the set-aside rate. Therefore, it is interesting to examine to what extent our simulation results of the Agenda 2000 scenario are sensitive to these assumptions. This is the purpose of this sensivity analysis.

Beyond the interest of such a sensitivity analysis in itself, the response of the likely impacts of the Agenda 2000 reform on the EU COP sector to the assumed evolution of both market prices and the set-aside rate is also interesting from a policy perspective. Indeed, whether the reduction in cereal intervention prices adopted in the Agenda 2000 CAP reform will allow the EU to export cereals without refunds is a crucial question. This obviously depends on the evolution of world market prices, internal market prices and the Euro/US\$ exchange rate. So far, a clear-cut answer to this question has not emerged from existing studies. On the other hand, the evolution of the set-aside policy, namely of

the mandatory rate of set-aside, is clearly dependent on the possibility for the EU to export cereals without refunds.

It is therefore logical, from both the sensitivity analysis and the policy points of view, to examine the sensitivity of simulation results simultaneously to the assumptions retained regarding the market prices and the mandatory set-aside rate evolution.

In the central scenario, by assuming a 10% decrease in the soft wheat market price and a 15% decrease in other cereal market prices, we implicitly assume that the EU could export non-subsidised soft wheat but that this possibility would be unlikely for other cereals. In the optimist scenario, we implicitly assume that exports of all cereals do no longer need any export refunds so that the set-aside policy is accordingly reduced. At reverse, the pessimist scenario implicitly rules out the possibility for the EU to export any non-subsidised cereals, so that the supply control, through the set-aside policy, is strengthened.

The results of our sensitivity analysis on main endogenous variables are reported in tables 6.18. and 6.19. Looking at the impacts on land uses and production levels of the central and the two variants of the Agenda 2000 scenario with respect to the 1998/99 levels, one may observe that the signs of the effects of the Agenda 2000 scenario are in general unchanged but that their magnitudes are substantially sensitive to the adopted assumptions on the evolution of market prices and the set-aside rate. For instance, whatever these adopted assumptions, our results show that the global production of cereals, oilseeds and protein crops increase with respect to the 1998/99 campaign. For cereals (respectively oilseeds) considered as a whole, the increase ranges from +2.90% (respectively +4.26%) in the pessimist scenario to +12.27% (respectively +14.20%) in the optimist scenario. In the same vein, the land allocated to oilseeds always decreases, between -12.41% in the pessimist scenario and -8.40% in the optimist one. On the other hand, the impact on the land allocated to cereals becomes positive (+1.48%) in the optimist scenario, compared to a decrease (-3.92%) in the central one. We may again underline that most of the increase in total land available for cropping is devoted to cereal production, suggesting that the set-aside policy is an effective mechanism to control cereals supply. The impacts on crop yields are quite comparable among the three scenarios. This comes from the fact that price and set-aside effects compensate for each other on these variables. In any case, they are mainly driven by trend effects.

From a macro-economic point of view, it is interesting to note that the unit land return and the total land remuneration become positive in the optimist scenario. One must also note that the total profit never decreases with respect to the initial level, even with pessimist assumptions. Finally, as expected, the level of public expenditures in terms of area direct payments is roughly the same in the three scenarios.

**Table 6.18. Sensitivity of the likely impacts of the Agenda 2000 scenario on the EU COP sector to price and set-aside assumptions**

Change in % w.r.t. the base levels	Pessimist scenario	Central scenario	Optimist scenario
<b>Land allocation</b>			
Soft wheat	-6.47	-2.36	+2.41
Barley	-7.72	-4.87	+0.87
Maize	-6.56	-4.26	+0.67
Oat	-6.71	-8.05	-0.09
Rye	-9.93	-11.69	-0.57
All cereals	-7.03	-3.92	+1.48
Rape	-8.03	-5.40	-4.11
Sunflower	-13.19	-10.28	-10.53
Soya	-34.10	-25.57	-20.53
All oilseeds	-12.41	-9.22	-8.40
Field peas	-0.88	-0.36	+0.04
All COP crops	-7.72	-4.64	0
<b>Production</b>			
Soft wheat	+3.44	+7.17	+11.87
Barley	+0.64	+4.75	+13.72
Maize	+5.61	+7.40	+11.37
Oat	-6.88	-5.14	+17.25
Rye	+1.28	+0.23	+9.45
All cereals	+2.90	+6.22	+12.27
Rape	+7.55	+12.26	+16.22
Sunflower	-0.12	+5.47	+9.03
Soya	+0.11	+10.96	+19.23
All oilseeds	+4.26	+9.92	+14.20
Field peas	+14.26	+17.43	+20.76
<b>Yields</b>			
Soft wheat	+10.59	+9.76	+9.23
Barley	+9.06	+10.12	+12.74
Maize	+13.02	+12.18	+10.63
Oat	-0.18	+3.16	+17.36
Rye	+12.43	+13.50	+10.08
Rape	+16.94	+18.67	+21.20
Sunflower	+15.06	+17.55	+21.87
Soya	+51.91	+49.08	+50.04
Field peas	+15.27	+17.85	+20.71
Land return (Euro/ha)	-11.37	-6.44	+4.30

**Table 6.19. Sensitivity analysis of the likely impacts of the Agenda 2000 scenario in terms of public expenditures and farm profits to price and set-aside assumptions**

Change in % w.r.t. the base levels	Pessimist scenario	Central scenario	Optimist scenario
<b>Direct payments</b>			
All cereals	+6.78	+10.74	+17.57
All oilseeds	-36.25	-33.55	-32.37
Field peas	-3.20	-2.69	-2.30
All COP crops	-2.25	+1.37	+6.88
Set aside	+69.40	+38.58	-8.09
Arable crops CMO	+5.14	+5.20	+5.34
<b>Change in Euro w.r.t. the reference year</b>			
Total profit	+550	+1486	+3304
Land remuneration	-1203	-742	+380
Other factors remuneration	+1753	+2228	+2924

## 6.6. Conclusion and policy recommendations

In this research report, we first describe a new economic model designed to perform policy simulations on the arable crops sector of the EU. This sector plays a central role in the EU agricultural sector, quantitatively as well as politically. Since the inception of the CAP, a huge public intervention regulates this sector and the arable crop CMO has often been the subject of intensive debates in international negotiations. The nature of this public intervention has changed with the 1992 and Agenda 2000 CAP reform where we observe a partial shift from price support to a mechanism of area direct payment and land set-aside.

The developed model, labelled MECOP for Maximum Entropy on Cereals, Oilseeds and Protein Crops, is particularly well-suited to analyse such reorientation of the public intervention. The main features/originalities of the model are the followings. MECOP is basically a partial equilibrium model focused on the representation of the supply side of the European COP sector. The specification of the model is firmly based on the production theory. The duality theory is used to represent technical constraints as well as the economic behaviour of arable crops producers. The land market is explicitly modelled, as we assume that land is a quasi-fixed but allocatable fixed factor. The main policy instruments of the arable crops CMO are also explicitly represented in the model, task facilitated by

the introduction of the land market. Therefore, this model allows to explore the economic implications of potential reforms of this CMO on many interesting variables, such as production levels, land uses, per hectare yields, public expenditures in the guise of area direct payments and farm profits. The same theoretical structure is applied to six European countries (Denmark, Germany, France, Italy, Spain and United Kingdom) that are assumed to produce nine COP crops (soft wheat, barley, maize, oat, rye, rape, sunflower, soya and field peas). The econometric estimation of the behavioural parameters is another original feature of the MECOP model. These parameters are estimated using the Generalised Maximum Entropy technique. This technique is for instance particularly recommended when collinearity between exogenous variables is important, as it is observed for output prices in the case of MECOP. Moreover, the introduction of inequality restrictions on these parameters is easily done with the technique and improves the efficiency of the estimation. In this report, we provide estimation results. We also compute and report the elasticities of land uses and productions with respect to prices, area direct payments and total available land. These elasticities may serve as input in other economic models.

We simulate with MECOP the impacts of the Agenda 2000 CAP reform and discuss, in the last part of the report, the results at the European level. Several quantitative analysis of this reform has already been performed but from these existing studies, it is difficult to get a clear picture of the impacts of the reform. They nearly all agree on the increases of cereals area and production but there are no longer a consensus on the magnitude of these increases. Results on other COP products are more mitigated and the macro-economic impacts (on public expenditures, farm profits) are rarely assessed. Therefore, we examine the impacts of the Agenda 2000 CAP reform on all these variables and moreover detail the impacts of each policy instrument. We finally perform some sensitivity analysis of these results to the levels of prices and set aside rate, as it is difficult to determine the evolution of these exogenous variables.

The main results of our simulations are the followings. Compared to a no-reform scenario, the application of the Agenda 2000 CAP reform as defined in our central scenario, will lead to an increase of cereals area (+3%) and to a decrease of oilseeds area (-4%). The increase of cereals production is limited to 1% as the reduction of cereal intervention prices has a significant negative effects on yields. The reduction of oilseeds area is largely governed by the alignment of oilseeds direct payments to cereals direct payments while the positive impacts on cereals area largely results from the change of the set aside commitment. From a macro-economic point of view, the application of the Agenda 2000 CAP reform will lead to only a slight increase of public expenditures, in the guise of area direct payments, compared to a the 1998/99 campaign. We also find a slight increase of farm profits and this will mainly benefit to the rewards of non land primary factors. On the other land, the income support will be less capitalised in the land, always compared to the 1998/99 campaign. Sensitivity analysis to

prices and set-aside assumptions proves that our macro-economic results are quite robust and that the signs of the effects on productions and land uses are also robust.

Therefore, from a political point of view, we can conclude that the Agenda 2000 CAP reform still allow to support farm incomes with i) only a slight increase public expenditures in the guise of area direct payments and ii) a significant reduction of cereal support prices that translate in benefits for cereal consumers. Moreover, the farm income support will become less capitalised in land values and conversely more in the rewards of other farm primary factors (mainly labour and capital). The reduction of cereal intervention prices will also ease the exports of cereals to the world market without export refunds. This has two crucial implications. Firstly, exporting without refunds will save budget expenditures and the overall impact of this reform on public expenditures for the arable crops CMO may become negative rather than positive. Secondly, the EU will be in better position (than without the Agenda 2000 CAP reform) for negotiating on the export competition at the WTO millenium round.

As far as the internal support dossier of these WTO negotiations is concerned, several points must be underlined. We already mention that the cereals production will increase which in turn, other things being equal, will increase the Aggregate Measure of Support (AMS). On the other hand, the reduction of the cereal intervention prices contributes to reduce the EU AMS and this second effect obviously dominates the first one. Thus, the Agenda 2000 CAP reform will lead a reduction of the "COP crop AMS" while slightly increasing area direct payments or the values of blue box measures. At this stage, it is important to note that, compared to a no-reform scenario, the Agenda 2000 CAP reform will favour the cereals production by only 1% and that it is more than likely that the EU consumption of cereals will increase by more than this percentage. So, at the end of the day, trade distortions of the arable crop CMO are reduced.

Our analysis also shows that the application of the Agenda 2000 CAP reform will reduce per hectare yields of nearly all COP crops, and therefore may have a positive effects on environment. On the other hand, the main weakness of this reform concerns the production of oilseeds. It is clear that the production of these critical products for the EU farm sector is not supported by this reform. Relaxing further the control of supply through the set aside policy will partially alleviate the negative effects on oilseed production but will mainly favour the production of cereals. The use of this instrument is therefore extremely tricky.

## APPENDIX

### Estimation results for the United Kingdom, Germany, Italy, Spain and Denmark

#### A.6.1. United Kingdom

**Table 6.20. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft Wheat	-30.882	-5601.671	13.245	-0.764**	5.830**	42.576*	302.589**
Barley	755.139**	-4784.991	10.143	-0.503**	4.804**	-23.344	197.894**
Rape	-665.628	-1229.055	1.771*	-4.512**	2.586*	82.402**	44.385

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.21. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$
Soft wheat	-528.97	-8685.57*	45.47**	567.67**
Barley	759.22	-1137.70	-61.69**	-99.92
Rape	-230.25	-1824.48**	16.53**	87.12**

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.22. Correlation coefficients between observed and estimated series**

COP crops	Land equations	Supply equations
Soft wheat	0.939	0.958
Barley	0.955	0.889
Rape	0.965	0.970

**Table 6.23. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.236	-0.162	-0.023
Barley	-0.488	0.436	-0.079
Rape	-0.107	-0.124	0.257

**Table 6.24. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.114	-0.103	-0.015
Barley	-0.236	0.275	-0.051
Rape	-0.051	-0.078	0.167

**Table 6.25. Estimates of price elasticities of COP crop supplies (year 1999; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.263 [0.085]	-0.123	-0.017
Barley	-0.362	0.487 [0.164]	-0.059
Rape	-0.082	-0.095	0.449 [0.252]

**Table 6.26. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.086	-0.077	-0.011
Barley	-0.174	0.204	-0.038
Rape	-0.039	-0.060	0.128

**Table 6.27. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\varepsilon_L^i$	$\varepsilon_L^y$	$\varepsilon_w^i$	$\varepsilon_w^y$
Soft Wheat	0.616 [0.372]	0.466	-0.048	-0.121
Barley	2.152 [0.565]	1.594	0.143	-0.058
Rape	0.469 [0.063]	0.360	-0.064	-0.301

### A.6.2. Germany

**Table 6.28. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft wheat	19.544	514.60 <sup>€</sup>	2.130	-0.468**	4.051**	35.186**	223.261
Barley	442.810	-4145.362**	10.436	-0.648**	5.286**	23.741	132.325**
Maize	-567.145**	-1102.642	2.965	-6.236**	5.514**	84.817**	64.575**
Oat	819.907**	-2683.087**	11.992**	-1.124**	4.134**	-29.374*	57.407
Rye	-136.490	-1054.664	2.328	-0.635**	3.790**	14.079	71.692
Rape	-64.809	-711.244*	1.373	-13.134**	2.635	367.129**	27.768

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.29. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$
Soft wheat	-341.24	-867.74	25.15	325.15**
Barley	406.74**	-1995.34	0.50	134.98**
Maize	-119.69	-1762.61	9.85**	118.87**
Oat	569.99**	-326.77	-46.97**	-136.75**
Rye	-497.22**	-2939.12	-14.70**	15.97
Rape	-18.58**	-760.21	26.17**	96.72**

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.30. Correlation coefficients between observed and estimated series**

COP crops	Land equations	Supply equations
Soft wheat	0.992	0.988
Barley	0.838	0.93
Maize	0.983	0.958
Oat	0.964	0.896
Rye	0.865	0.864
Rape	0.906	0.890

**Table 6.31. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Rye	Rape
Soft wheat	0.230	-0.098	-0.013	-0.040	-0.073	-0.005
Barley	-0.100	0.268	-0.012	-0.035	-0.063	-0.005
Maize	-0.064	-0.055	0.285	-0.022	-0.040	-0.003
Oat	-0.592	-0.504	-0.068	1.264	-0.372	-0.027
Rye	-0.309	-0.263	-0.035	-0.107	0.592	-0.014
Rape	-0.014	-0.012	-0.002	-0.005	-0.009	0.053

**Table 6.32. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Rye	Rape
Soft wheat	0.155	-0.056	-0.006	-0.032	-0.058	-0.005
Barley	-0.068	0.153	-0.006	-0.028	-0.050	-0.004
Maize	-0.043	-0.031	0.139	-0.018	-0.032	-0.003
Oat	-0.398	-0.288	-0.033	1.025	-0.294	-0.024
Rye	-0.208	-0.150	-0.017	-0.087	0.468	-0.013
Rape	-0.009	-0.007	-0.001	-0.004	-0.007	0.048

**Table 6.33. Estimates of price elasticities of COP crop supplies (year 1999 ; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Maize	Oat	Rye	Rape
Soft wheat	0.155 [0.013]	-0.061	-0.008	-0.025	-0.045	-0.003
Barley	-0.097	0.341 [0.082]	-0.011	-0.034	-0.061	-0.004
Maize	-0.043	-0.037	0.310 [0.119]	-0.015	-0.027	-0.002
Oat	-0.649	-0.552	-0.074	2.656 [1.270]	-0.408	-0.030
Rye	-0.222	-0.189	-0.025	-0.077	0.484 [0.058]	-0.010
Rape	-0.012	-0.010	-0.001	-0.004	-0.008	0.165 [0.120]

**Table 6.34. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Rye	Rape
Soft wheat	0.096	-0.035	-0.004	-0.020	-0.036	-0.003
Barley	-0.065	0.148	-0.005	-0.027	-0.048	-0.004
Maize	-0.029	-0.021	0.093	-0.012	-0.021	-0.002
Oat	-0.437	-0.316	-0.036	1.123	-0.322	-0.027
Rye	-0.149	-0.108	-0.012	-0.062	0.336	-0.009
Rape	-0.008	-0.006	-0.001	-0.003	-0.006	0.041

**Table 6.35. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\varepsilon_L^i$	$\varepsilon_L^y$	$\varepsilon_w^i$	$\varepsilon_w^y$
Soft wheat	0.877 [0.335]	0.542	0.002	-0.012
Barley	0.762 [0.242]	0.734	-0.051	-0.132
Maize	0.487 [0.025]	0.326	-0.112	-0.194
Oat	4.485 [0.139]	4.918	0.312	-0.929
Rye	2.341 [0.247]	1.681	0.142	0.044
Rape	0.106 [0.012]	0.092	-0.031	-0.147

### A.6.3. Italy

**Table 6.36. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft wheat	144.062	-3640.878	10.099	-0.368	3.310	-9.120	132.791
Barley	429.609	-2470.548	6.892	-1.588**	3.452*	-7.682	67.158
Maize	0.811	-4037.959	3.742	-4.659**	7.073*	145.920**	224.146**
Sunflower	-504.607	-850.330	0.891	-44.670**	2.054	347.509**	30.146
Soya	-0.001	-2074.655	2.373	-2.364**	3.339**	-5.304	69.613

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.37. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^j b_j / e_j}{\sum_{j=1}^j 1 / e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^j b_j / e_j}{\sum_{j=1}^j 1 / e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^j g_j / e_j}{\sum_{j=1}^j 1 / e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^j g_j / e_j}{\sum_{j=1}^j 1 / e_j} - g_i \right)$
Soft wheat	-49.92	-3806.10	-29.69	34.52
Barley	168.25	-1889.76	-5.97	46.53
Maize	-34.69	-4283.32**	30.93**	442.93**
Sunflower	-14.93	-881.00	7.74**	46.31**
Soya	-68.71	-2304.08	-3.01	59.57

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.38. Correlation coefficients between observed and estimated series**

COP crops	Land equations	Supply equations
Soft wheat	0.972	0.844
Barley	0.804	0.698
Maize	0.858	0.910
Sunflower	0.803	0.754
Soya	0.835	0.880

**Table 6.39. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Sunflower	Soya
Soft wheat	0.508	-0.250	-0.179	-0.008	-0.253
Barley	-0.466	0.583	-0.078	-0.003	-0.110
Maize	-0.055	-0.013	0.162	-0.001	-0.013
Sunflower	-0.029	-0.007	-0.005	0.037	-0.007
Soya	-0.487	-0.114	-0.081	-0.003	0.975

**Table 6.40. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Sunflower	Soya
Soft wheat	0.217	-0.106	-0.072	-0.007	-0.129
Barley	-0.199	0.247	-0.031	-0.003	-0.056
Maize	-0.023	-0.005	0.066	-0.001	-0.007
Sunflower	-0.012	-0.003	-0.002	0.033	-0.003
Soya	-0.207	-0.048	-0.033	-0.003	0.495

**Table 6.41. Estimates of price elasticities of COP crop supplies (year 1999; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Maize	Sunflower	Soya
Soft wheat	0.691 [0.355]	-0.165	-0.118	-0.005	-0.167
Barley	-0.419	1.095 [0.571]	-0.070	-0.003	-0.099
Maize	-0.041	-0.010	0.167 [0.045]	-0.001	-0.010
Sunflower	-0.023	-0.005	-0.004	0.300 [0.271]	-0.005
Soya	-0.375	-0.087	-0.003	-0.003	1.172 [0.422]

**Table 6.42. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Maize	Sunflower	Soya
Soft wheat	0.143	-0.070	-0.048	-0.005	-0.085
Barley	-0.179	0.222	-0.028	-0.003	-0.050
Maize	-0.018	-0.004	0.049	-0.001	-0.005
Sunflower	-0.010	-0.002	-0.002	0.026	-0.003
Soya	-0.160	-0.037	-0.025	-0.002	0.381

**Table 6.43. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\epsilon_{L}^y$	$\epsilon_{L}^y$	$\epsilon_w^l$	$\epsilon_w^y$
Soft wheat	2.521 [0.67]	1.668	0.278	-0.171
Barley	1.098 [0.16]	0.987	0.117	-0.466
Maize	0.045 [0.05]	0.097	-0.111	-0.128
Sunflower	0.271 [0.01]	0.053	-0.001	-0.272
Soya	0.422 [0.11]	0.882	-0.493	-0.802

#### A.6.4. Spain

**Table 6.44. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft wheat	477.833	-1808.954	2.134	-0.349**	1.965*	-8.024	107.763**
Barley	-99.755	-5933.927	19.929**	-0.092*	1.951*	-11.509*	199.334*
Maize	475.236*	-213.364	1.094	-2.912**	3.034	13.674	94.047**
Oat	646.673*	-578.538*	1.463*	-1.979**	1.505*	-2.616	14.339**
Sunflower	-128.695	-248.649	0.300	-0.363**	0.660	16.519**	23.208

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.45. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$
Soft wheat	1299.692	744.941	-47.943*	13.554
Barley	-1347.776	-8563.438	30.443	258.728
Maize	154.875	256.526	1.705	99.221*
Oat	314.519**	-105.187	-5.722**	5.727
Sunflower	-421.310	-526.713	21.517	37.409**

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.46. Correlation coefficients between observed and estimated series**

COP crops	Land equations	Supply equations
Soft wheat	0.954	0.318
Barley	0.968	0.529
Maize	0.358	0.709
Oat	0.530	0.336
Sunflower	0.846	0.787

**Table 6.47. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Sunflower
Soft wheat	0.489	-0.299	-0.018	-0.012	-0.052
Barley	-0.127	0.233	-0.023	-0.016	-0.068
Maize	-0.032	-0.098	0.285	-0.004	-0.017
Oat	-0.060	-0.185	-0.011	0.249	-0.032
Sunflower	-0.092	-0.283	-0.017	-0.011	0.260

**Table 6.48. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Sunflower
Soft wheat	0.241	-0.181	-0.011	-0.008	-0.074
Barley	-0.062	0.141	-0.015	-0.011	-0.097
Maize	-0.016	-0.059	0.186	-0.003	-0.024
Oat	-0.030	-0.112	-0.007	0.174	-0.046
Sunflower	-0.045	-0.171	-0.011	-0.008	0.370

**Table 6.49. Estimates of price elasticities of COP crop supplies (year 1999; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Maize	Oat	Sunflower
Soft wheat	0.376 [0.071]	-0.186	-0.011	-0.008	-0.074
Barley	-0.104	0.439 [0.248]	-0.019	-0.011	-0.097
Maize	-0.011	-0.033	0.131 [0.034]	-0.003	-0.024
Oat	-0.064	-0.197	-0.012	0.174 [0.349]	-0.046
Sunflower	-0.058	-0.180	-0.011	-0.008	0.370 [0.049]

**Table 6.50. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Maize	Oat	Sunflower
Soft wheat	0.150	-0.113	-0.007	-0.005	-0.046
Barley	-0.051	-0.116	-0.012	-0.009	-0.080
Maize	-0.005	-0.020	0.063	-0.001	-0.008
Oat	-0.032	-0.119	-0.008	0.185	-0.049
Sunflower	-0.029	-0.109	-0.007	-0.005	0.236

**Table 6.51. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\epsilon_L^i$	$\epsilon_L^{y_i}$	$\epsilon_w^i$	$\epsilon_w^{y_i}$
Soft wheat	0.920 [0.165]	0.574	-0.075	-0.118
Barley	1.203 [0.627]	0.990	0.045	-0.211
Maize	0.302 [0.020]	0.103	-0.217	-0.108
Oat	0.570 [0.029]	0.608	0.061	-0.285
Sunflower	0.871 [0.159]	0.555	0.008	-0.044

### A.6.5. Denmark

**Table 6.52. Structural parameter estimates**

COP crops	$b_i$	$c_i$	$d_i$	$e_i$	$f_i$	$g_i$	$h_i$
Soft Wheat	-28.877	-2598.582**	9.700	-18.503**	6.053*	478.124	74.379
Barley	649.722	-3959.204**	12.042*	-0.500**	4.502*	-30.259	116.549
Rape	-165.869	-487.154	0.860	-3.878**	2.088*	5.311	13.908

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.53. Reduced-form parameter estimates**

COP crops	Constant in the land equation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Constant in the supply equation $c_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J b_j / e_j}{\sum_{j=1}^J 1/e_j} - b_i \right)$	Trend impact on land allocation $\frac{1}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$	Trend impact on production level $h_i + \frac{f_i}{e_i} \left( \frac{\sum_{j=1}^J g_j / e_j}{\sum_{j=1}^J 1/e_j} - g_i \right)$
Soft wheat	-30.901	-2785.627*	26.619**	235.504**
Barley	213.665*	-2997.283	-31.705**	-26.181
Rape	-182.764	-868.765	5.085	24.525**

\*\* : Significant at the 0.05 level; \* : Significant at the 0.10 level

**Table 6.54. Correlation coefficients between observed and estimated series**

COP crops	Land equations	Supply equations
Soft wheat	0.969	0.957
Barley	0.980	0.854
Rape	0.935	0.938

**Table 6.55. Estimates of price elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.057	-0.040	-0.005
Barley	-0.045	0.203	-0.149
Rape	-0.034	-1.000	0.912

**Table 6.56. Estimates of direct payment elasticities of cultivated areas (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.024	-0.021	-0.004
Barley	-0.018	0.106	-0.143
Rape	-0.014	-0.525	0.878

**Table 6.57. Estimates of price elasticities of COP crop supplies (year 1999; price elasticities of COP crop supplies for a given allocation in brackets)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.297 [0.248]	-0.035	-0.004
Barley	-0.040	0.585 [0.404]	-0.133
Rape	-0.027	-0.774	1.219 [0.513]

**Table 6.58. Estimates of direct payment elasticities of COP crop supplies (year 1999)**

COP crops	Soft wheat	Barley	Rape
Soft Wheat	0.021	-0.018	-0.004
Barley	-0.016	0.095	-0.128
Rape	-0.011	-0.406	0.680

**Table 6.59. Estimates of elasticities of cultivated areas and output supplies with respect to total available land and variable input price (year 1999)**

COP crops	$\epsilon_L^i$	$\epsilon_L^{y_i}$	$\epsilon_w^i$	$\epsilon_w^{y_i}$
Soft Wheat	0.055 [0.023]	0.047	-0.011	-0.257
Barley	1.768 [0.865]	1.577	0.046	-0.363
Rape	1.360 [0.112]	1.053	-0.216	-0.680



## **7. A MODEL OF THE EU'S DAIRY AND BEEF PRODUCING SECTOR**

### **Agenda 2000 and Beyond: Impact of milk quota abolition on milk and beef production in EU Member States**

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#### **7.1. Introduction**

The objective of this part of the project (i.e., subtask 2.2) was to develop a tool for simulating policy reform in the milk-producing sector of the European Union. The fundamental structure of the market regulations for the EU milk sector has remained unchanged since the introduction of milk quotas in 1984. Milk production is a major sector in EU agriculture: about 22 million dairy cows are kept on nearly one million holdings, although not all of these holdings can be classified as commercial dairy farms. In 2000, about 120 million tons of milk were produced, for which national quotas (deliveries to dairies and direct sales) amounted to about 118.4 million tons. A structural milk surplus of about 10 per cent above domestic requirements is produced annually.

Milk prices are supported by market intervention arrangements for butter and skim milk powder. In recent years, however, the combination of high tariffs on dairy products and internal supply control on raw milk has probably been more responsible for maintaining milk prices within the EU at levels well above the level implied by world market dairy product prices.

Despite years of stability and relative prosperity for the sector, reform of the EU's dairy policy is on the agenda. The EU's exposed position within the international trading community regarding its large volumes and expenditure levels for subsidised dairy products is one factor suggesting reform will be needed. In addition, there are strong internal pressures from producers and dairy companies for relaxation of quota limits. Moreover, arrangements for other CAP-regulated products have been shifting away from market price support towards lower market prices in conjunction with direct payments to farmers. Agenda 2000 introduced such an arrangement for the dairy sector, to take effect as from 2005. In the mean time, a small relaxation in quota limits has already started to be implemented. An urgent question is whether this policy direction can be continued for milk, especially when the consequences of such policy changes now have to be envisaged in the context of an enlarging Union. These few observations sketch the policy context within which our model has been designed.

The model developed in this research fills a gap in the stock of research tools available to EU decision makers. Although some national studies exist, there is no model available that depicts the milk-producing sector at EU level in sufficient detail to articulate the types of policies currently implemented or under discussion.

Our model has been constructed according to some clearly defined scientific principles. First, it is strongly based in production theory. In particular, it uses to the full the framework provided by recent developments in duality theory for analysing production in the presence of supply constraints. Second, it has been constructed in a way that maximises the contribution of empirical information on the sector studied. The main behavioural relationships of the model are econometrically estimated, using a combination of time series sample data and non-sample information on technical, biological, structural and institutional parameters of the sector. Third, the model is fully dynamic, allowing for immediate short-run adjustment of outputs and variable feed use, but also for more gradual adjustment of the livestock numbers and land allocated to forage and grazing.

A special feature of the model is that beef and dairy production are fully integrated in the model, both as regards the underlying decision making model and in specifying the constraints and trade-offs between the two types of production. This combined representation has been considered important for several reasons. First, in many parts of the EU milk is produced on farms that also engage in beef production from non-dairy herds. On these farms, the competition for resources and the income trade-off between suckler cows and dairy cows is explicit. When policy changes and farmers react, it is likely that these farms will find themselves "on the margin", more so than specialist farms with a less diversified investment in one or other of these two enterprises and hence less flexibility to react.

Equally importantly, the dairy herd is a major source of beef production. Therefore, changes in policy regarding the production of milk will, in so far as they affect dairy cow numbers, have an important effect on the quantity of beef produced. Policy makers need models that explicitly recognise joint production of commodities, in order to avoid displacing problems in the regulation of one commodity into the market of a related commodity.

Finally, because of the joint production of milk and beef, the incomes not only of mixed livestock producers but also those of specialist dairy producers are dependent on beef prices and policies. For a complete study of the profitability of the dairy sector, its role as a supplier of beef must also be taken into account.

The specific objectives of the research reported here were, therefore, to develop a simulation tool and to provide policy simulations with a strong empirical and theoretical basis that would be able to:

- represent the full complexity of current and likely future policy measures in the dairy sector;
- compare different policy options, either for milk separately or for the milk-beef complex;
- compare policy impacts between the different EU Member States;
- provide realistic time paths of adjustment, taking into account the different rates of adjustment of various dimensions of the production process;
- calculate the likely consequences for budget outlays on different types of direct payment to producers.

The model reported in this chapter represents the current outcome of our research efforts. The simulations shown are a subset of what has been performed, and do not represent the model's full capabilities (for example, budgetary transfers are not analysed in detail as between types of payment and country recipient). However, they have been selected for their interest to a range of different interest groups and their relevance to the current policy debate.

This chapter is organised as follows. Section 2 presents the philosophy and specification of the Wageningen milk and beef production model for the EU-15. It also gives an overview of its role as a policy simulator. Section 3 deals with the technical specification of the model, describes the estimation procedure and presents and discusses estimation results. Section 4 reports and discusses simulation results. Finally, section 5 concludes. It first provides a discussion on the sensitivity of simulation results to alternative assumptions regarding the degree of decoupling of beef and dairy direct payments, the initial levels of quota rents and the yield growth. Then, it draws some policy conclusions and recommendations.

## **7.2. A tool for simulating dairy policy reform**

### ***7.2.1. Philosophy of the model***

The underlying philosophy of the model is summarised by several key strategic features:

- similar treatment for all countries;
- theoretical consistency;
- use of prior information (estimates from the literature, technical coefficients, etc.);
- econometric estimation in order to allow time series data to "correct" prior information on individual parameters.

Before presenting an overview of the model, it is useful to give the reasons for this philosophy, and to explain its implications.

- *Similar treatment for all countries.* Simulated scenarios of policy reform may have significant implications for individual countries. Using a standard methodology reduces the risk that the pattern of changes across countries is distorted or biased by country-specific methodological choices. Nonetheless, some country-specific features (dummy variables, country-specific time trends) have been used sparingly to take account of different timing of entry into the EU, the impact of BSE, etc.

- *Theoretical consistency.* Rigorous theoretical constraints are imposed on the model when estimating. These restrictions derive from the underlying assumptions of production theory, reflecting logical constraints on technological trade-offs and the assumption of rational producer decision-making. They provide additional information that improves the efficiency of estimation and helps to prevent counter-intuitive results when simulating.

- *Use of all prior information.* The time series data used are limited and its quality is variable across countries. Therefore, as well as the time series data base, it is important to use all possible information sources (previous literature, technical coefficients, information about the structure of the livestock sector in each country) in a systematic way. This prior information is expressed in the form of stochastic constraints and forms an input into the estimation process. In addition, constraints that would be imposed anyway during simulation (such as the long-run relationship between dairy cows and milk output, or between grazing and forage land and stock numbers) are incorporated into the prior information used when estimating, so that the econometric estimates are consistent with these relationships.

- *Possibility for data to "correct" prior information on individual parameters.* Prior information may be of a rather general nature, or come from a study on just one country. Thus, data are allowed to "shift" prior values when their signal is statistically significant.

### **7.2.2. Overview of the model**

The model is designed to simulate the impact of dairy and beef policy instruments on milk and beef outputs, feed used as an input into milk and beef production, the stocks of dairy cows and beef (suckler) cows, and the allocation of land to beef and dairy production (forage and grazing).

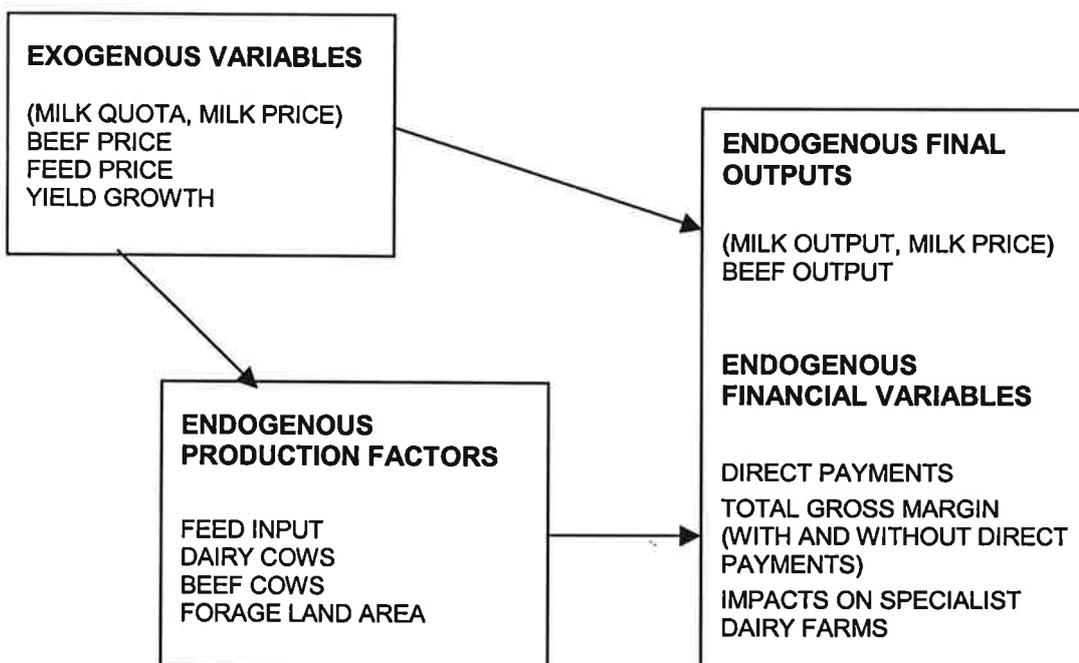
The model can simulate in two different policy settings: with milk supply constrained by quota, and without any quota restrictions on milk supply. When milk supply is constrained by quota, milk price is exogenously determined and it is assumed that milk production in each Member State equals the quota limit in that Member State. When milk is not constrained by quota, the shadow milk supply functions

determine milk production in each Member State, in conjunction with price, which is now endogenous. To solve for milk supply and milk price, the shadow milk supply functions of each Member State are aggregated to form an EU total milk supply function, which interacts with a demand function at EU level. As a result of this interaction, an endogenous milk price is determined, along with national supplies.

In the model, milk and beef outputs are determined in the current period, as a function of current prices (or prices and milk quota levels when quotas are in force). The adjustment of the three quasi-fixed factors (dairy cows, suckler cows and land) does not occur instantaneously. Instead, these factors begin their adjustment with a one-year lag, and take several periods to adjust fully to a price or policy change. Thus, the full impact of a price or policy change takes a number of periods to complete.

An overview of the model is given in Figure 7.1.

**Figure 7.1. Schematic Overview of the Model**



The theoretical model contains the following relationships:

- *Profit function.* The profit function relates to the dairy and beef sector. It expresses the gross margin (without direct payments) as a function of beef and feed prices, quasi-fixed factors and milk output.

- *Beef and veal output supply.* Beef and veal output supply is a function of current beef and feed prices, current levels of quasi-fixed factors and milk output.

- *Feed input demand.* Feed input demand is a function of current beef and feed prices, current levels of quasi-fixed factors and milk output.

The last two equations are derived directly from the profit function. One therefore finds the same parameters in these last two functions as in the profit function. The three equations (profit function, beef and veal output and feed input) form a mutually consistent set of equations describing short-run profit maximisation. These three equations are estimated jointly in order to allow restrictions on parameters that appear in more than one equation.

- *Milk output (shadow price function).* Milk output supply is a function of current milk price, current beef and feed prices and current levels of quasi-fixed factors. This relationship is not directly observable from past behaviour, because EU milk supply has been constrained by quotas since 1984 and has not been free to respond to price. The milk output supply function is based on the expression for the shadow price of milk, which is derived by algebraic means from the profit function. This derivation gives us those parameters of the milk supply function that describe the responsiveness of milk supply to changes in milk price, to other prices and to quasi-fixed factors. To get the height (position) of the function, it is calibrated using exogenous information about quota rents and structural features of the milk-producing sector in each Member State.

- *Dairy cow stock equation, suckler cow stock equation, land use equation.* The long-run versions of these three equations can also be derived by algebraic means from the profit function. These equations share many of the parameters that appear in the profit function. We assume that these quasi-fixed factors need more than one period to adjust to price and policy changes. The adjustment equations for these factors are dynamic, and embed the long-run expression (derived from the profit function). They are therefore estimated empirically, preserving the links between the long-run parameters and the corresponding parameters of the profit function.

- *Accounting equations.* In addition to the above behavioural equations, there are a number of accounting identities that are used to calculate direct payments, and gross margins with and without direct payments. The direct payment equations calculate the total payments under the various headage payment schemes. Each equation uses the payment rate for the relevant animal type, and the number of animals of that type. The number of specific animals of each type is derived from the dairy and suckler cow stock numbers with the appropriate lag. In this way, the number of animals (calves, bulls, suckler cows, etc.) qualifying for payments also adjusts under different policy scenarios, via the dairy and suckler cow stock adjustments.

- *Aggregate demand for milk*. This equation is not estimated, but is instead calibrated using an extraneous estimate of the demand elasticity and the quantity of milk supplied in 2000. In the simulations, this function is adjusted (height and elasticity) to reflect different exogenous assumptions about aggregate demand conditions.

This completes the overview of the structure of the model. It is useful to distinguish between the model in two different modes: as a model for estimation (i.e. to be confronted with data in order to estimate unknown parameters), and as a model for simulation. Table 7.1 summarises the "content" of the model in each of these modes.

**Table 7.1. Composition of the model in estimation and simulation modes**

Equation	MS/ EU?	Estimation mode	Simulation mode	
			With quotas	Without quotas
Profit function	MS	√		
Beef and veal output supply	MS	√	√	√
Feed input demand	MS	√	√	√
Milk supply function				
Milk supply = quota	MS		√	
Milk supply as function of price	MS			√
Aggregate demand for milk	EU			√
Dairy cow adjustment	MS	√	(√)	√
Suckler cow adjustment	MS	√	√	√
Forage and grazing land adjustment	MS	√	√	√
Animals slaughtered	MS		√	√
Gross margin calculation	MS		√	√
Totals of various direct payments	MS		√	√
Impacts on specialist dairy farms	MS		√	√

(1) The column MS/EU denotes whether the equation is specified at the level of each Member State, or at aggregate EU level.

(2) √ denotes that this equation forms part of the model in the corresponding mode.

(3) When quotas are in force, dairy cow adjustment follows yield, given quota (see paragraph 7.3.3).

Table 7.1 indicates that most equations occur in the model in both modes. There are, however, some exceptions. For example, the milk supply response functions cannot be directly estimated, since past

data do not yield any direct evidence on how producers respond to changes in the milk price. Therefore, this equation cannot be directly estimated. Nonetheless, most of its parameters are estimated econometrically in the profit function, from which it is derived. As explained, the aggregate demand function uses assumed parameters and is calibrated on the situation in a given year. This equation is necessary to "close" the model, and to allow a full solution when quotas are no longer in force and milk price becomes fully endogenous. However, as the model is designed primarily to study the detailed impacts of policy and market changes on the milk and beef producing sectors, the details of the demand side of the market are not articulated in the model. Trends in consumption of raw milk (due, for example, to rising income) or removal of a segment of the EU market (due, for example, to the abolition of export subsidies for dairy products) are captured by horizontal shifts of an appropriate size in the aggregate demand for raw milk at EU level.

The profit function forms part of the model to be estimated. Estimating the profit function along with the demand and supply functions improves the quality of the estimates, and ensures that all the estimated parameters are mutually consistent in representing an integrated production sector. However, it is not the estimated profit function that is used to calculate gross margins in the simulations, but rather the more direct definition of gross margins as the sum of revenues from milk and beef production, *minus* the cost of the variable input feed.

The observations in the previous two paragraphs explain the main asymmetries in Table 7.1. The following section describes the structure of the model in algebraic form.

### **7.2.3. Description of the behavioural model**

#### **7.2.3.1. Variable inputs and outputs**

Economic decisions regarding dairy and beef production are modelled using a restricted profit function framework. The normalized restricted profit function is defined as:

$$\pi = f_0(p, z) \tag{1}$$

where  $p$  is a  $2 \times 1$  vector of variable netput prices ( $p_1$ =normalised price of beef and veal,  $p_2$ =normalised price of feed),  $z$  is a  $5 \times 1$  vector ( $z_1$ =trend,  $z_2$ =land (grazing and forage area),  $z_3$ =suckler cows,  $z_4$ =dairy cows, and  $z_5$ =milk output). Full definitions of these variables are contained in the data paragraph 7.3.4.

Hotelling's Lemma yields the beef and veal output supply ( $q_1$ ) and feed input demand ( $q_2$ ) functions:

$$q_i = f_i(p, z) , \quad i = 1, 2 \tag{2}$$

### 7.2.3.2. Adjustment of quasi-fixed factors

The (conditional) shadow price functions for the quasi-fixed factors are given by:

$$\frac{\partial \pi}{\partial z_j} = g_j(p, z) = -p_j^s, \quad j = 2, 3, 4 \quad (3)$$

Rearranging these functions yields the equations for the optimal level of each of the quasi-fixed factors:

$$z_j^* = z_j(p_j^s, p, z_{(j)}) \quad (4)$$

where  $z_{(j)}$  is the vector of all quasi-fixed factors *except*  $z_j$ .

The adjustment equations are of the form:

$$z_{j,t} = \lambda_j z_{j,t-1}^* + (1 - \lambda_j) z_{j,t-1}, \quad j = 2, 3, 4, \text{ where } 0 < \lambda_j < 1 \quad (5)$$

### 7.2.4. Policies that can be simulated with the model

A wide range of policies targeting the milk-producing sector can be analysed with the model. These policies are summarised below.

- *Supply control*
- Changing levels of milk quota allocated to each Member State.
- Removal of milk quotas.
- *Direct payments for milk production*
- Payment per cow.
- Payment per hectare.
- Payment per ton of quota.

Different assumptions are possible about producers' perceptions of these payments. They can be depicted as fully coupled, totally decoupled or partially coupled. Various experiments can also be performed regarding the profile over time of these payments; for example, they could be made degressive (i.e., reducing over time).

- *Milk price support*

- The effects of different levels of support price (linked to the intervention prices of butter and skim milk powder via the intervention milk price equivalent and its relation to market prices) in the with-quota scenarios.
- The effect of a floor price in the without-quota scenarios.

In addition, simulations of *changes in beef sector policy* can be performed. In particular, we can simulate the effect of changes in beef price, and changes in the various direct payments per head for different types of beef animals. Given the interdependence of beef and dairy production, it is useful to evaluate policy packages that affect both sectors simultaneously.

Finally, the effect of *changes in the cereal price*, insofar as they affect the price of feed, can also be analysed. Not only are beef and milk output affected by feed price changes but so too is the amount of feed used for dairy and beef production, and the allocation of land to grazing and forage production.

Changes in the use of these policy instruments can be simulated, giving results year by year for each Member State over a 20-year time horizon. Of course, simulating over such a long time horizon, with a model whose parameters are based on a data set that does not extend beyond the 1990s, cannot give accurate *forecasts* of what will happen, in real time, if a given policy is adopted. These simulations can, however, allow the *comparison of different policy alternatives* in a realistic and consistent way, and can explore the sensitivity of the sector to different types of policy instrument.

### **7.3. Specification and estimation of the model**

This section deals with the technical specification of the model. In the first paragraph (7.3.1), the detailed algebraic structure of the model is presented. Paragraph 7.3.2 discusses the estimation method used, known as "mixed estimation" because it combines information from sample data along with non-sample information regarding likely values of the unknown parameters. Paragraph 7.3.3 explains the type of non-sample information that was used, and how it was systematically assembled in a form that could be processed by the mixed estimation technique. Paragraph 7.3.4 describes the sample data used for estimation, and the data used to specify the scenarios for the simulations. Paragraph 7.3.5 describes the estimation sequence and the goodness-of-fit of the estimated models. Paragraph 7.3.6 explains how the simulation results at sector level were translated into whole-farm gross margin changes for specialist dairy farms. The rationale for these calculations is also explained.

### 7.3.1. Parameterisation of the model

#### 7.3.1.1. Profit function and netput equations

We assume a normalised quadratic functional form for the profit function:

$$\pi = \alpha_0 + \sum_{i=1}^2 \alpha_i p_i + \sum_{k=1}^5 \beta_k z_k + \frac{1}{2} \sum_{i=1}^2 \sum_{j=1}^2 \alpha_{ij} p_i p_j + \frac{1}{2} \sum_{k=1}^5 \sum_{l=1}^5 \beta_{kl} z_k z_l + \sum_{i=1}^2 \sum_{k=1}^5 \gamma_{ik} p_i z_k \quad (6)$$

with associated netput functions:

$$q_i = \alpha_i + \sum_{j=1}^2 \alpha_{ij} p_j + \sum_{k=1}^5 \gamma_{ik} z_k, \quad i = 1, 2 \quad (7)$$

Implicit in the short-run model are the shadow price relationships for the quasi-fixed factors and rationed milk output (Moschini, 1988:320). These relationships are obtained by differentiating the profit function with respect to the quasi-fixed factor (showing the amount by which profit would change following a one-unit change in the level of the fixed factor). This defines (minus) the shadow price of the quasi-fixed factor. Optimal adjustment of quasi-fixed factor would involve changing the level of the quasi-fixed factor until its shadow price is equal to its market price (or its opportunity cost to the farmer). In this framework, milk quota is treated analogous to the constrained quasi-fixed factors (Moschini, 1988). Therefore, implicit optimal levels of the quasi-fixed factors and milk output can be obtained by solving:

$$\frac{\partial \pi}{\partial z_j} = -p_j^s, \quad j = 2, 3, 4, 5 \quad (8)$$

#### 7.3.1.2. Milk supply response

Three different shadow price relationships for the constrained milk output ( $z_5$ ) can be obtained by differentiating the profit function with respect to milk output and setting each in turn equal to *minus* the shadow price of milk. The difference involves which other variables in the equation are assumed to adjust when the farmer adjusts milk output.

$\left. \frac{\partial \pi}{\partial z_5} \right|_{\text{all fixed factors constant}}$  shows the change in profit when the quota constraint is relaxed by one unit,

without any adjustment in stock levels or land allocated to dairying. Only the variable input, feed, can be adjusted in order to achieve an increase in milk supply.

$\frac{\partial \pi}{\partial z_s} \Big|_{\text{land constant}}$  shows the change in profit when the quota constraint is relaxed by one unit and stock levels adjust to optimal levels but land allocated to dairying remains fixed. Thus, in addition to changes in feed, there is also rearrangement of stocking levels.

Finally,  $\frac{\partial \pi}{\partial z_s} \Big|_{\text{all factors variable}}$  shows the change in profit when the quota constraint is relaxed by one unit and stock levels and land allocated to dairying adjust to optimal levels.

The shadow milk supply functions corresponding to these different assumptions are, respectively:

$$z_5 = m_1(p^s, p, z_{(5)}), \quad z_5 = m_2(p^s, p, z_{(3,4,5)}) \quad \text{and} \quad z_5 = m_3(p^s, p, z_{(2,3,4,5)}) \quad (9)$$

where  $z_{(i,j)}$  is a reduced vector of quasi-fixed factors (i.e. quasi-fixed factors  $i$  and  $j$  are no longer included in the vector).

The corresponding supply responses have the following interpretations.  $\frac{\partial m_1}{\partial p^s}$  shows the response of milk output to a change in the shadow price when there is no adjustment in stock levels or land.  $\frac{\partial m_2}{\partial p^s}$  shows the response of milk output to a change in the shadow price, when stock levels adjust but land remains fixed.  $\frac{\partial m_3}{\partial p^s}$  shows the response of milk output to a change in the shadow price when stock levels and land adjust.

In the simulations, milk supply responds without any constraints on quasi-fixed factors, which are allowed to adjust according to their adjustment equations. However, the conceptual differentiation between these three "levels" of milk supply response is useful when defining the prior information for key parameters in the system.

According to the Le Chatelier principle (Chambers, 1988:145-147), we expect the following:

$$\frac{\partial m_1}{\partial p^s} < \frac{\partial m_2}{\partial p^s} < \frac{\partial m_3}{\partial p^s} \quad (10)$$

$\frac{\partial m_1}{\partial p^s}$  shows the milk supply response conditional on fixed levels of dairy cows, suckler cows and land. This implies a response consisting of a relatively costly upward deviation from trend yield, given the existing number of dairy cows. It is therefore expected to be rather small.

It is worth noting that the  $\frac{\partial m_i}{\partial p^s}$  are all long-run responses, in the sense that they all assume full adjustment of whichever variables are allowed to adjust. For example,  $\frac{\partial m_2}{\partial p^s}$  denotes the change in milk supply relative to a change in shadow milk price after stock levels have fully adjusted. Clearly, the length of time required for full adjustment will depend on how quickly stock levels can adjust. Rates of adjustment are discussed in the next paragraph.

The most constrained shadow milk response function ( $z_s = m_1(p^s, p, z_{(s)})$ ) corresponding to this specification is given by:

$$z_s = -\frac{1}{\beta_{ss}}(p^s + \beta_s + \sum_{k=1}^4 \beta_{ks} z_k + \sum_{i=1}^2 \gamma_{is} p_i) \quad \text{with } \beta_{ss} < 0 \quad (11)$$

It follows that  $\frac{\partial m_1}{\partial p^s} = \frac{-1}{\beta_{ss}}$  (12)

We can also show that:

$$\frac{\partial m_2}{\partial p^s} = \frac{-1}{\beta_{ss} + \delta} \quad (13)$$

and  $\frac{\partial m_3}{\partial p^s} = \frac{-1}{\beta_{ss} + \delta + \varphi}$  (14)

where  $\delta$  and  $\varphi$  can be expressed in terms of other parameters of the profit function, and expressions involving quasi-fixed factors. With additional assumptions, these expressions can be expressed in terms of milk yield and stocking rates for beef and dairy cows.

The constraints given in (3) imply:

$$0 < \delta < |\beta_{ss}| \quad \text{and} \quad 0 \leq \varphi < |\beta_{ss}| - \delta \quad (15)$$

The objective of this decomposition of the milk supply response is to facilitate the choice of priors for the parameters involved, and thereby to make sure that the constraint given by equation (10) is incorporated into the estimated elasticities. This procedure is discussed in more detail in paragraph 7.3.3.

### 7.3.1.3. Quasi-fixed factors

The optimal levels of the quasi-fixed factors are:

$$z_j^* = \frac{1}{\beta_{jj}} \left( p_j^s - \beta_j - \sum_{k \neq j} \beta_{kj} z_k - \sum_{i=1}^2 \gamma_{ij} p_i \right), \quad j = 2, 3, 4 \quad (16)$$

We assume that the quasi-fixed factors adjust to their optimal levels according to the partial adjustment mechanism  $z_{j,t} = \lambda_j z_{j,t-1}^* + (1 - \lambda_j) z_{j,t-1}$ . This gives the following adjustment equations:

$$z_{2,t} = -\frac{\lambda_2}{\beta_{22}} \left( -p_{2,t-1}^s + \beta_2 + \beta_{12} z_{1,t-1} + \beta_{32} z_{3,t-1} + \beta_{42} z_{4,t-1} + \beta_{25} z_{5,t-1} + \gamma_{12} p_{1,t-1} + \gamma_{22} p_{2,t-1} \right) + (1 - \lambda_2) z_{2,t-1} \quad (17)$$

$$z_{3,t} = -\frac{\lambda_3}{\beta_{33}} \left( -p_{3,t-1}^s + \beta_3 + \beta_{13} z_{1,t-1} + \beta_{23} z_{2,t-1} + \beta_{43} z_{4,t-1} + \beta_{53} z_{5,t-1} + \gamma_{13} p_{1,t-1} + \gamma_{23} p_{2,t-1} \right) + (1 - \lambda_3) z_{3,t-1} \quad (18)$$

$$z_{4,t} = -\frac{\lambda_4}{\beta_{44}} \left( -p_{4,t-1}^s + \beta_4 + \beta_{14} z_{1,t-1} + \beta_{24} z_{2,t-1} + \beta_{34} z_{3,t-1} + \beta_{54} z_{5,t-1} + \gamma_{14} p_{1,t-1} + \gamma_{24} p_{2,t-1} \right) + (1 - \lambda_4) z_{4,t-1} \quad (19)$$

Note that, in the above adjustment equations, all right-hand side variables have a one-period lag. This solves the simultaneity problem present in the original system, and which facilitates estimation.

### 7.3.2. Estimation of the equation system by mixed estimation

Several complications have to be considered when estimating the model described in the previous paragraph. First, within the estimation period 1973-1995, two different policy regimes operated. Before 1984, there was no restriction on milk output, while from 1984 onward milk output is restricted by quota. The simplest solution would be to estimate two separate models, i.e., the unrestricted supply system for the first sub-period (a profit function model), and a restricted supply system for the second sub-period (a cost function model).

However, due to the short time series relative to the number of parameters to be estimated, combining both models but adding further assumptions would allow for more efficient information. If it is assumed that the underlying production technology has not changed, there exists a direct relationship between the restricted and unrestricted profit functions describing producer behaviour (Fulginiti and Perrin, 1993). Exploiting this linkage enables efficient estimation using information from both periods to determine one set of parameters. The disadvantage of the latter approach is that one ends up with a highly non-linear model.

To avoid these complications, the final approach chosen here is more indirect. The restricted profit function and its derived netput functions are estimated for the whole sample period. Because the quantity of milk has a mixed endogenous/exogenous character, in principle a simultaneous equations estimator should be used. However, because Hausman tests in general rejected the endogeneity hypothesis, non-simultaneous estimation was applied to all countries.<sup>105</sup>

The short time series and poor quality of some of the data, together with the fact that some variables show collinearity also made it difficult to obtain meaningful and significant parameters in all equations. Given the importance of robust and sensible parameters in the simulation model, a solution to this problem has to be found.

Following Jongeneel (2000), a mixed estimation procedure was applied, which allows sample and non-sample information to be combined. The non-sample information consists of the usual (non-stochastic) theoretical constraints (such as symmetry of the Hessian matrix, and homogeneity of degree one in prices of the profit function) on the one hand, and other forms of prior information. The other prior information, which is included by specifying stochastic constraints, reflects prior ideas regarding specific model coefficients, based on previous economic research (e.g., input and output price elasticities estimated in other studies), as well as agronomic characteristics (e.g., feed conversion characteristics, milk and beef yields per cow) regarding specific coefficients. Unlike the theoretical restrictions, which are assumed to hold exactly, the prior parameter values are imposed in the form of stochastic relationships to reflect a priori uncertainty about the validity of these values.

This paragraph explains how the prior information was incorporated into the estimation process. The following paragraph explains how prior information was systematically assembled for most of the key parameters.

Assume the behavioural model, consisting of the three equations (1), (2) and (3), may be written as  $y = X\beta + u$ , where  $y$  denotes a vector of endogenous variables ( $\Pi, q_1, q_2$ ), and  $X$  represents a block diagonal matrix of explanatory variables, with on its diagonal  $X_1, X_2$  and  $X_3$  respectively, where  $X_i$  denotes the matrix of explanatory variables associated with the  $i$ -th equation in the system. Denoting the number of time periods by  $T$  and the number of explanatory variables in  $X_i$  by  $K_i$ ,  $X_i$  has dimensions  $(T \times K_i)$  and  $X$  is a  $(3T \times K_1 + K_2 + K_3)$  matrix.  $X_i$  and  $X_j$  matrices may have common explanatory variables (e.g.,  $X_2 = X_3$ ).  $\beta$  is the parameter vector which is defined as  $(\beta_1, \beta_2, \beta_3)$ . The

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<sup>105</sup> Simultaneity was generally rejected, except for Belgium/Luxembourg (meat and feed), the United Kingdom (meat) and the Netherlands (feed).

$\beta_1$  and  $\beta_2$  vectors may have common elements (e.g., cross-equation symmetry restrictions).  $u$  is an  $(3T \times 1)$  vector  $(u_1, u_2, u_3)$  of disturbance terms. Adding the stochastic restrictions gives:

$$\begin{pmatrix} y \\ p \end{pmatrix} = \begin{pmatrix} X \\ P \end{pmatrix} \beta + \begin{pmatrix} u \\ v \end{pmatrix}; \quad E \begin{bmatrix} u \\ v \end{bmatrix} = 0, \quad \text{Var} \begin{bmatrix} u \\ v \end{bmatrix} = \begin{pmatrix} \Phi & 0 \\ 0 & V_0 \end{pmatrix} \quad (20)$$

with  $p = P\beta + v$  representing the stochastic restrictions.<sup>106</sup> If there are  $N_p$  pieces of prior information there are  $N_p$  stochastic restrictions.  $p$  is then a  $(N_p \times 1)$  vector and  $P$  a  $(N_p \times K_1 + K_2 + K_3)$  matrix. The uncertainty is reflected in the variances attached to the prior estimates, which are summarised in an  $(N_p \times N_p)$  matrix  $V_0$ . Usually  $\Phi$   $(3T \times 3T)$  is unknown and has to be estimated ( $\hat{\Phi}$ ), before GLS can be applied (cf. for example Judge et al, 1988:446). The (feasible) mixed estimator is:

$$b_m = \left[ X' \hat{\Phi}^{-1} X + P' V_0^{-1} P \right]^{-1} \left( X' \hat{\Phi}^{-1} y + P' V_0^{-1} p \right) \quad (21)$$

When, in addition,  $N_r$  non-stochastic restrictions of the form  $R\beta = r$  are imposed on this system (with  $R$   $(N_r \times K_1 + K_2 + K_3)$  and  $r$  a scalar of dimension  $N_r$ ), a restricted mixed estimator  $b_m^*$  can be derived (Jongeneel, 2000:116):

$$b_m^* = b_m + (Z' \Psi^{-1} Z)^{-1} R' \left[ R (Z' \Psi^{-1} Z)^{-1} R' \right]^{-1} (r - R b_m) \quad (22)$$

with  $b_m$  the mixed estimator as before, and:

$$Z = \begin{pmatrix} X \\ P \end{pmatrix} \quad \text{and} \quad \Psi = \begin{pmatrix} \hat{\Phi} & 0 \\ 0 & V_0 \end{pmatrix} \quad (23)$$

where  $Z$  is a matrix of  $(3T + N_p \times K_1 + K_2 + K_3)$  and  $\Psi$  an  $(3T + N_p \times 3T + N_p)$ . A routine for the mixed estimator was written in the statistical package EVIEWS.

### 7.3.3. Prior information

This paragraph describes how a comprehensive set of prior information was drawn up for the main parameters in the model. Two guiding principles were used. First, it was important to maintain consistency between the various elasticities in the system. To this end, very explicit expressions were derived showing the decomposition of elasticities as weighted sums of more basic elasticities. These

<sup>106</sup> If, for example,  $P = (1, 0, 0, \dots)$  and  $p = 0.5$  this implies a prior estimate for the first element of the parameter vector, say  $\beta_{11}$ , of 0.5.

expressions made the linkages between the various elasticities in the model more transparent. Priors for parameters were chosen so as to respect these relationships. Second, we aimed to incorporate all relevant prior information (estimated elasticities found in the literature, knowledge about the structure of the sector in each country, technological constraints and so on) in order to make the priors reflect the characteristics of individual countries.

It is not possible in this paragraph to explain in detail how all the prior information used was obtained and amalgamated. We illustrate the procedures with some examples.

First, we consider the equations for beef output supply and feed input demand (equations (2) and (3)). Their general form is:

$$B = f(p^b, p^f, DCS, BSS, LAND, TR, END) \quad (24)$$

$$F = g(p^b, p^f, DCS, BSS, LAND, TR, END) \quad (25)$$

with, as dependent variables, B beef output ( $q_1$ ), and F feed input ( $q_2$ ), and as explanatory variables, beef and feed prices, stocks of dairy cows DCS ( $z_4$ ) and suckler cows BSS ( $z_3$ ), land ( $z_2$ ) and a trend variable ( $z_1$ ). The notation used in this section has been changed to improve transparency.

#### 7.3.3.1. Beef supply

Beef output B is the sum of beef from dairy cow cullings (DC) and beef from slaughtered other animals (BS) or  $B = DC + BS$ .<sup>107</sup>

The amount of meat produced from dairy or other animals is the product of the number of slaughterings (NDC, NBS) of these animals and the average slaughtered weight (WDC, WBS), or:

$$B = NDC * WDC + NBS * WBS \quad (26)$$

The own-price beef supply elasticity can be derived as a weighted average of the elasticities of dairy and other animals with respect to the price of beef as:

$$\varepsilon_B^{p^b} = \frac{DC}{B} * \varepsilon_{DC}^{p^b} + \frac{BS}{B} * \varepsilon_{BS}^{p^b} \quad (27)$$

Because DC is the product of NDC and WDC, the price elasticity of beef supplied from dairy origin may be written as:<sup>108</sup>

<sup>107</sup> Note that  $DC = f_d(DCS)$  and  $BS = f_b(DCS, BSS)$ .

<sup>108</sup> To derive this (and the following) relationship(s), (constant) linear linkages between variables are assumed, which make it possible to approximate partial derivatives by ratios of the averages of the concerned variables.

$$\varepsilon_{DC}^{p^b} = \varepsilon_{NDC}^{p^b} + \varepsilon_{WDC}^{p^b} \quad (28)$$

that is, as the sum of the elasticity of dairy cow slaughterings with respect to the price of beef and the elasticity of the average dairy cow slaughter weight with respect to the beef price.<sup>109</sup> This linkage makes it possible to distinguish between slaughterings and the associated herd adjustments, and slaughter weight management.

As a consequence the own-price elasticity of beef output may now be decomposed as:

$$\varepsilon_B^{p^b} = \frac{DC}{B} * (\varepsilon_{NDC}^{p^b} + \varepsilon_{WDC}^{p^b}) + \frac{BS}{B} * (\varepsilon_{NBS}^{p^b} + \varepsilon_{WBS}^{p^b}) \quad (29)$$

Since beef from dairy cows has the character of a by-product, it is expected to be rather insensitive to beef price changes ( $\varepsilon_{NDC}^{p^b} = \varepsilon_{WDC}^{p^b} = 0$ ). The other elasticities are less easy to establish. If producers perceive a beef price increase as permanent, they will probably react by temporarily reducing the number of slaughterings in order to enlarge their herd and by that increasing future beef supply. If, however, producers perceive a beef price increase as transitory, they are likely to increase cullings and may even cull animals that have not yet achieved their optimal slaughter weight.

In an analogous way, the cross price elasticity of beef output with respect to the price of feed (input) may be written as:

$$\varepsilon_B^{p^f} = \frac{DC}{B} * (\varepsilon_{NDC}^{p^f} + \varepsilon_{WDC}^{p^f}) + \frac{BS}{B} * (\varepsilon_{NBS}^{p^f} + \varepsilon_{WBS}^{p^f}) \quad (30)$$

The elasticity of beef output, B, with respect to the quantity of milk, M, is equal to:

$$\varepsilon_B^M = \frac{DC}{B} * (\varepsilon_{NDC}^M + \varepsilon_{WDC}^M) + \frac{BS}{B} * (\varepsilon_{NBS}^M + \varepsilon_{WBS}^M) \quad (31)$$

The elasticity of beef output with respect to the dairy cow stock (DCS) is equal to:

$$\varepsilon_B^{DCS} = \frac{DC}{B} * (\varepsilon_{NDC}^{DCS} + \varepsilon_{WDC}^{DCS}) + \frac{BS}{B} * (\varepsilon_{NBS}^{DCS} + \varepsilon_{WBS}^{DCS}) \quad (32)$$

Assuming the influence of the dairy cow stock on the average slaughtering weights of both categories (dairy cows, other animals) is negligible, the elasticity relationship may be further simplified as:

$$\varepsilon_B^{DCS} = \frac{DC}{B} * \varepsilon_{NDC}^{DCS} + \frac{BS}{B} * \varepsilon_{NBS}^{DCS} \quad (33)$$

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<sup>109</sup> Cross product terms of partial derivatives are assumed to be small enough to neglect them.

where the latter elasticity reflects the competition (or complementarity)<sup>110</sup> between dairy cow herds and other animal herds (competition for land, forage, labour). After the introduction of milk quotas in 1984, competition at the margin between dairy and beef animals seems to have increased (suckler cow numbers have increased for most countries since 1984). This becomes clearer after recognising that  $\epsilon_{NBS}^{DCS}$  may be replaced by the elasticity of the other beef animal stock (BSS) with respect to the dairy cow stock (see the simplification from (32) to (33)), giving:

$$\epsilon_B^{DCS} = \frac{DC}{B} * \epsilon_{NDC}^{DCS} + \frac{BS}{B} * \epsilon_{BSS}^{DCS} \quad (34)$$

In an analogous way, the elasticity of beef output with respect to the other beef animal stock (BSS) may be written as:

$$\epsilon_B^{BSS} = \frac{DC}{B} * \epsilon_{DCS}^{BSS} + \frac{BS}{B} * \epsilon_{NBS}^{BSS} \quad (35)$$

Here again, the first right hand side elasticity reflects the competition between dairy and beef herds.

Finally, the elasticity of beef output with respect to land is:

$$\epsilon_B^{LAND} = \frac{DC}{B} * \epsilon_{DCS}^{LAND} + \frac{BS}{B} * \epsilon_{BSS}^{LAND} \quad (36)$$

### 7.3.3.2. Feed demand

Feed input  $F$  is the sum of feed used by dairy cows ( $FD$ ) and feed used by beef animals ( $FB$ ), or  $F = FD + FB$ .<sup>111</sup>

The amount of feed demanded per animal category is the product of the stock of dairy and other animals (DCS, BSS) and their corresponding feed intakes per animal ( $FID$ ,  $FIB$ ), or:

$$F = DCS * FID + BSS * FIB \quad (37)$$

Because the dairy cow feed consumption ( $FD$ ) is the product of DCS and  $FID$ , the input demand price elasticity of feed for dairy cows may be written as:

$$\epsilon_{FD}^{p^f} = \epsilon_{DCS}^{p^f} + \epsilon_{FID}^{p^f} \quad (38)$$

<sup>110</sup> A distinction has to be made between specialised beef-producing countries and countries where dairying and beef production are complementary.

<sup>111</sup> The implicit focus is on cereals, energy-rich and protein-rich feeds. Forage is not directly accounted for, but is assumed to be taken up by the LAND variable in the model.

The own-price elasticity of feed input can be derived as a weighted average of the elasticities of dairy and other animals with respect to the price of feed as:

$$\varepsilon_F^{p^f} = \frac{FD}{F} * (\varepsilon_{FID}^{p^f} + \varepsilon_{DCS}^{p^f}) + \frac{FB}{F} * (\varepsilon_{FIB}^{p^f} + \varepsilon_{BSS}^{p^f}) \quad (39)$$

or as the weighted sum<sup>112</sup> of the elasticity of dairy cow feed intake with respect to the price of feed and the elasticity of the dairy cow stock with respect to the feed price, and the same elasticities with respect to beef animals. This linkage makes it possible to distinguish between changes in feed intensity per animal and the associated herd adjustments.

Analogously, the elasticity of feed input with respect to the beef price can be derived as:

$$\varepsilon_F^{p^b} = \frac{FD}{F} * (\varepsilon_{FID}^{p^b} + \varepsilon_{DCS}^{p^b}) + \frac{FB}{F} * (\varepsilon_{FIB}^{p^b} + \varepsilon_{BSS}^{p^b}) \quad (40)$$

where the dairy cow elasticities ( $\varepsilon_{FID}^{p^b}, \varepsilon_{DCS}^{p^b}$ ) are likely to be very small. Increasing beef prices (relative to feed prices) is likely to increase feed consumption per animal. The effect of a beef price increase on the stock of beef animals is ambiguous (see above).

The elasticity of beef feed input (F) with respect to the quantity of milk M is equal to:

$$\varepsilon_F^{y^m} = \frac{FD}{F} * (\varepsilon_{FID}^{y^m} + \varepsilon_{DCS}^{y^m}) + \frac{FB}{F} * (\varepsilon_{FIB}^{y^m} + \varepsilon_{BSS}^{y^m}) \quad (41)$$

The elasticity of feed intake per animal,  $\varepsilon_{FID}^{y^m}$ , will be the most important one in the (very) short run. Next comes dairy cow herd adjustment, which may, depending on the degree of competition between dairying and beef producing, spill-over to the beef herd (BSS).

The elasticity of feed input with respect to the dairy cow stock (dairy herd) DCS is equal to:

$$\varepsilon_F^{DCS} = \frac{FD}{F} * (\varepsilon_{FID}^{DCS} + 1) + \frac{FB}{F} * (\varepsilon_{FIB}^{DCS} + \varepsilon_{BSS}^{DCS}) \quad (42)$$

and with respect to the beef herd (BSS):

$$\varepsilon_F^{BSS} = \frac{FD}{F} * (\varepsilon_{FID}^{BSS} + \varepsilon_{DCS}^{BSS}) + \frac{FB}{F} * (\varepsilon_{FIB}^{BSS} + 1) \quad (43)$$

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<sup>112</sup> It should be noted that there is no a priori reason why the weights FD/F and FB/F should correspond to the weights DC/B and BS/B of the previous point.

Both elasticities are likely to be roughly equal to, respectively, the shares of dairy cows and beef animals in feed consumption, with a potential downward correction, again depending on the complementarity or competition between dairy cow herds and other animal herds (competition for land, forage, labour).

A similar decomposition can be made for the elasticity of feed demand with respect to land.

#### *7.3.3.3. Rationale for the elasticity decomposition*

It turns out that a significant refinement in the determination of the priors (i.e., the prior values assigned to parameters) can be achieved by exploiting the information about the shares that dairy cows and suckler cows have, directly and indirectly, in total beef and veal output and in feed consumption. The elasticities are decomposed as weighted sums of more basic elasticities, whose values can more easily be assigned on the basis of biological or technological considerations, or using prior estimates from the literature. With a few exceptions, these basic elasticities are likely to be rather homogeneous across countries. At the same time, the weights used to combine them reflect country-specific structural information (for example, the relative importance of dairy cows as a source of beef production). These weights are obtained from the data base.

One exception to the assumed homogeneity of basic elasticities relates to the issue of complementarity and competition between dairying and beef production. In a number of cases, this trade-off emerges as an important parameter about which a judgement must be made on a country-by-country basis. From simple time-series regressions, it appeared that 10 out of 15 Member States show a negative correlation between dairy and suckler cow numbers.<sup>113</sup> Countries with a positive correlation or non-significant correlation are Germany, Greece, Italy and Sweden.<sup>114</sup> These estimated parameters for each Member State were used where relevant in establishing the priors.

The priors were constructed in the form of elasticities and then, since the equations are linear, were transformed into prior values for the parameters by adjusting them with appropriate ratios of sample means.

#### *7.3.3.4. Priors for other parameters*

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<sup>113</sup> Regressing dairy cows on suckler cows for respectively the whole period (73-95) and the milk quota period (84-95). Results are available from the authors upon request.

<sup>114</sup> The suckler cow data for Sweden are of low quality, so these results should be treated cautiously.

Previous points 7.3.3.1 and 7.3.3.2 illustrate in some detail how prior values were assembled for the parameters  $\alpha_{ij}$  and  $\gamma_{ik}$  in equations (7). No priors are used for the parameters  $\alpha_i, \beta_j$  and  $\beta_{j\ell}$   $i=1,2, j=2,\dots,5$ . In this point, we give a brief description of the method whereby the prior values were derived for the parameters  $\beta_{j\ell}$  for  $j, \ell = 2, \dots, 5$ .

Unlike the parameters  $\alpha_{ij}$  and  $\gamma_{ik}$  which appear in the netput functions and for which estimates appear in the literature, the parameters  $\beta_{j\ell}$  (appearing in the profit function and in the optimal fixed-factor equations) are more difficult to relate to observable technical coefficients or to previous research results.

Our starting point is to assume a set of prior values for the three own-price conditional (i.e., no adjustment of other quasi-fixed factors or milk) elasticities for land, suckler cows, and dairy cows, and for the elasticity of milk based on equation (12) (i.e., no adjustment in quasi-fixed factors). It should be noted that these parameters must be non-positive because of the concavity of the profit function in quasi-fixed factors.

Some prior information on the short-run milk supply response ( $-1/\beta_{55}$ ) is available from the literature. Thijssen (1992) using a number of different approaches but focusing on the pre-quota period (1970-82), obtained short-run elasticities in the range of 0.10-0.13 and long-run elasticities of 0.27 and 0.32. These elasticities correspond to the functions  $z_5 = m_1(p^s, p, z_{(5)})$  and  $z_5 = m_3(p^s, p, z_{(2,3,4,5)})$  respectively. Boots (1999: 65) who studied the Dutch dairy sector using a panel data set containing 9365 observations on 1961 farms for the period 1973/74-1992/93, found milk supply elasticities of 0.26 and 0.43 depending on the model specification. These elasticities already assume adjustments in quasi-fixed factors, notably dairy cows, and therefore correspond to  $z_5 = m_3(p^s, p, z_{(2,3,4,5)})$ . Comparing these two sets of estimates suggests that milk supply elasticities have remained rather stable over time, at least in the Netherlands. They depend on production structure or technology characteristics rather than on policy regimes.

Guyomard et al (1996: 214-215) analysed the French dairy sector using a cost function approach. Their estimates are based on a sample of 1599 farms, taken from the FADN. Using the estimated slope-parameter of the marginal cost function with respect to milk and multiplying this by the milk price/milk quantity-ratio (evaluated at the reported sample means), gave a short-run (constrained) milk supply elasticity of  $1.67 \cdot 10^{-3}$ . For Finland, Kola (1991) obtained a supply elasticity of 0.5, which seems to have a medium-run character and hence allows adjustments in quasi-fixed factors. These estimates are rather consistent in suggesting that the most constrained shadow milk elasticity is under 0.2, and with adjustments in quasi-fixed factors, an elasticity of 0.5 or less.

Since, when dairy cow numbers are fixed, milk supply increase has to come from an above-trend yield increase, some differentiation based on per country yield levels might be considered. There is evidence that cows with a relatively low yield level can more easily achieve an increase of, say, 5 per cent than cows that are already producing at relatively high yield levels.<sup>115</sup>

Once a prior belief about the most constrained elasticity has been formed, this can be translated into a prior on the parameter  $\beta_{55}$  according to the relationship  $\beta_{55} = -1/\varepsilon_{milk}^{p_m} \cdot (\bar{p}_m / \bar{z}_5)$  with  $\varepsilon_{milk}^{p_m}$  denoting the corresponding milk supply elasticity and  $\bar{p}_m$  and  $\bar{z}_5$  representing price and quantity of milk evaluated at the relevant sample mean. Using the prior information about the short-run by assuming a short-run supply elasticity of 0.10, implies that the prior value for  $\beta_{55}$  is fixed as  $-(1/0.1)(\bar{p}_m / \bar{z}_5)$ .

With respect to the elasticities involving some adjustment in quasi-fixed factors, the studies quoted above show more variation. This is even more so when non-European studies are examined (see below, paragraph 7.4.2). It is therefore difficult to specify reliable a priori beliefs with respect to the ratio of short- to medium-run response.

From equations (17) to (19), we see that each coefficient  $\beta_{kk}$  is directly related to the elasticity of each quasi-fixed factor with respect to its "price" since:

$$\beta_{kk} = \frac{\lambda_k p_k}{\varepsilon_{z_k}^{p_k} z_k} \quad (44)$$

In the case of dairy cows, "price" has to be interpreted as *input costs associated with dairy cows* (Boots, 1999: 56). For the Netherlands, Boots (1999: 65) obtained own-price input demand elasticities for dairy cows ranging from -0.3 to -0.5. We therefore base the value of  $\beta_{44}$  on an assumed elasticity of -0.4.

A similar reasoning for  $\beta_{33}$  (suckler cow equation) was also used. With respect to suckler cows no reliable prior information was available. An own-price elasticity of -0.4 was also assumed here, and was used to construct a prior value for  $\beta_{33}$ .

Finally, an own-price (conditional) elasticity of demand for land of -0.1 was assumed, in order to derive prior values for  $\beta_{22}$ .

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<sup>115</sup> This suggests that low national yields not only reflect low genetic quality, but also indicate sub-optimal feeding regimes.

Next, in order to be able to use the expression in (2.40) to fix prior values for  $\beta_{22}$ ,  $\beta_{33}$  and  $\beta_{44}$ , values for the adjustment coefficients  $\lambda_j$  are needed. These are assumed to be  $\lambda_2 = 0.2$ ,  $\lambda_3 = 0.6$ , and  $\lambda_4 = 0.7$ .<sup>116</sup> This leads finally to a set of prior values for  $\beta_{22}$ ,  $\beta_{33}$  and  $\beta_{44}$  which are then inserted into stochastic constraints, so that they may be modified by interaction with the data where necessary.

Having assigned priors for  $\beta_{j\ell}$ ,  $j = \ell$ , it is also useful to form some prior expectations for the parameters  $\beta_{j\ell}$ ,  $j \neq \ell$ . We began by setting  $\beta_{25} = \beta_{35} = 0$ , on the grounds that increasing milk output will not affect optimal levels of land and suckler cow stocks directly but only indirectly via dairy cow adjustments. This left four parameters to which priors must be assigned, namely  $\beta_{23}$ ,  $\beta_{24}$ ,  $\beta_{34}$  and  $\beta_{45}$ . These parameters can be expressed as functions of extraneous estimates for stocking rates, "competition" between beef and dairy, and yield, on the one hand, and the parameters  $\beta_{22}$ ,  $\beta_{33}$  and  $\beta_{44}$ . The parameters  $\beta_{23}$ ,  $\beta_{24}$ ,  $\beta_{34}$  and  $\beta_{45}$  are all involved in the expressions  $\delta$  and  $\varpi$ , which were defined in point 7.3.1.2. and for which inequality restrictions are also present. These restrictions are also used to further constrain and improve the consistency of the corresponding parameter estimates.

Our procedure for expressing these parameters ( $\beta_{23}$ ,  $\beta_{24}$ ,  $\beta_{34}$  and  $\beta_{45}$ ) as functions of the own-price response parameters ( $\beta_{22}$ ,  $\beta_{33}$  and  $\beta_{44}$ ) involves the assumption that milk yield and stocking rates are following trends over time that are largely exogenous to price and policy developments. In the case of milk yield, there is ample evidence that milk yields in the EU have been following a long-run trend that has resisted movements in real prices and only momentarily faltered at the moment of introducing milk quotas. However, we considered that further analysis was needed in order to support the assumption that stocking rates are exogenous in the long run.

In order to obtain estimates for aggregate stocking densities, weights must be assigned to dairy and suckler cows, and other grazing animals, in order to arrive estimate trends in total stocking densities. In order to establish these weights, various technical information was used.

The daily feed input requirement for dairy cows (550 kg live weight), expressed in "feed unit milk" (FUM) can be approximated by  $4696 + 439.M + 0.7293.M^2$ , where  $M$  stands for the daily yield in kg (PR, 1980: 159). For a dairy cow with a yield of 4000kg/year the average daily intake is 9595 FUM, which is more or less comparable to the requirement of a suckler cow (including pregnancy). The

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<sup>116</sup> These are the plausible parameters based on preliminary analysis, and are used in constructing the prior values for other parameters. These values are used as stochastic priors for the parameters themselves during estimation, so that data have been permitted to "correct" them before arriving at final estimates.

roughage intake of high yielding dairy cows is estimated to be 2.5 kg dry matter of roughage per 100kg live weight. High yielding cows (550 kg live weight) have a potential calculated dry matter roughage intake of 13.75 kg per day. In order to achieve the high yields often supplementary feeding with compound feeds is necessary to satisfy the total energy (and protein) requirements. On average 1 kg compound feed replaces 0.5 kg dry matter of roughage (PR, 1980: 160).<sup>117</sup>

Assuming grass has an average FUM value of 151 and 0.160 kg dry matter per kilogram of product (PR, 1980: 165), a suckler cow needs an intake of 10.16 kg dry matter of roughage to satisfy its complete (energy) requirement. The average milk yield in the EU15 in 1995 was estimated at 5279kg (EU, 1999, T/328). To achieve this yield a dairy cow would need a roughage intake of about 12kg (dry matter), without needing a compound feed supplement. The average forage and grazing requirement of a suckler cow will therefore lie in between 0.7 and 0.9 that of a dairy cow.

As a proxy for the contribution to stocking density of other roughage using animals, the requirements of sheep, the main other grazing animals category, is used as a basis. The FUM requirement of sheep (ewes and lambs) is estimated to be on average 1300 FUM per day (PR, 1980, 153). Satisfying this need requires a daily dry matter intake of roughage of 1.3 kg. The weight for sheep is then equal to 0.1 times the weight of a dairy cow.

Using these weights and the livestock numbers over the period 1975-1996, the total stocking density for EU15 has been rather constant at between 0.7 and 0.8 dairy cow equivalents per hectare of land used for forage and grazing (see Figure 7.2).

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<sup>117</sup> With small amounts of added compound feed (<3kg) replacement rates of about 0.3 and with high amounts of added compound feed (>7kg) replacement rates of about 0.6 are found.

Figure 7.2. Evolution of stocking rates in EU15

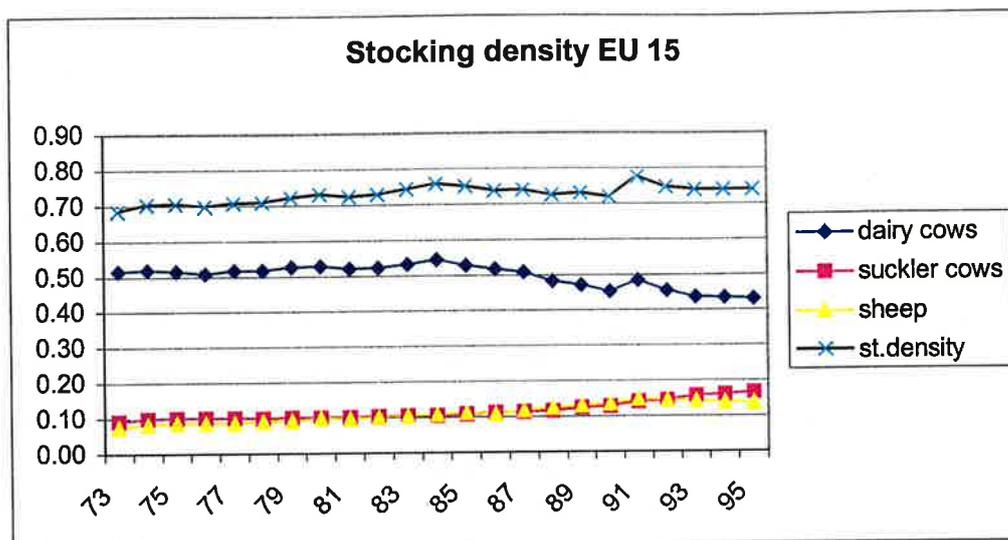


Figure 7.2 shows the development of the stocking density over time for the EU15, and the contributions of the different animal categories to it. As can be seen it supports the assumption that the long-run stocking density is rather stable. Table 7.16, in appendix 1, shows significant differences in stocking density over countries. The lowest densities are in Ireland and Spain, the highest in the Netherlands and Denmark. Part of these differences can be traced back to differences in land quality, climate and feeding systems. Except for Portugal, the stocking densities are fairly stable over time for all Member States.<sup>118</sup> Therefore, the stocking density relationship is a good candidate for a long-run condition that should be satisfied.

With respect to the suckler cow stock equation, some prior ideas about the "competition" coefficient between suckler and dairy cows were developed. Following the introduction of the milk quota in 1984, the decline in the dairy cow stock was partly compensated by an increase in suckler cows. The average substitution rate was 4 suckler cows for 10 dairy cows, while in more recent years the rate was close to 1 for 1 (European Commission, 1997: 10). In countries where dairy and suckler cow holding is very specialised, an increase in dairy cow numbers due to quota enlargement or quota abolition, at first sight, is likely to have little or no effect on suckler cow numbers (no intra-firm substitution). However, if at the margin dairy and suckler cows are combined operations and/or firms can easily switch

<sup>118</sup> Portugal shows an over time decline of stocking density in the period 1973-1984, with a stable stocking density thereafter.

between the two types of operation, changes in quota policy can induce a trade-off, or "competition" effect.

Since the mid 1980s the number of holdings with dairy cows has declined by about 7% per year, while the number of holdings with suckler cows has increased by about 2% per year. The empirical observations can be summarised as implying that  $-1 < \partial z_3 / \partial z_4 (= \sigma) \leq 0$  with an average value for the EU12 in the post-quota period of about  $-0.4$ . Farm structure survey data was used to further differentiate the prior information at country level. For each country, four types of farm operations are distinguished, i.e., dairying, rearing and fattening, mixed dairying and rearing and fattening, and a miscellaneous group, other mixed farming. Dairy farms are divided into specialised and mixed dairying/rearing. We made assumptions about the competition parameter on each type of farm (for example,  $\sigma = -1$  for mixed dairying/rearing farms,  $\sigma = -0.3$  for specialist dairy farms,  $\sigma = -0.8$  on mixed livestock farms,  $\sigma = 0$  on specialist rearing and fattening farms). We then obtained a weighted average of these basic assumed values using the share of dairy cows in on each type of farm as weights. This provided a set of prior values for the competition parameter. These priors were then incorporated in stochastic constraints, and used in the estimation of the suckler cow stock adjustment equation.

This point has given a non-exhaustive account of the way in which prior values were assigned to key parameters in the system. These prior values were then incorporated in the estimating system in the form of stochastic constraints, as described in paragraph 7.3.2. Where there was more uncertainty about a prior value, a larger variance was given to the corresponding stochastic element.

The following paragraph (7.3.4) describes the data used and its sources. The two final paragraphs of this section (7.3.5 and 7.3.6) explain the estimation sequences and the quality of the results of the econometric estimation.

#### **7.3.4. Data: Definitions and sources**

The data used in the model come from the SPEL data base/Eurostat, FADN and other official sources. Information regarding policy variables (institutional prices, direct payments) comes from the relevant legislation in the Official Journal (OJ). Table 7.2 lists the data series used to obtain the econometric estimates. Data was available for all Member States for the period 1973 to 1995. Figures for Luxembourg are included with those of Belgium unless explicitly stated otherwise.

Table 7.3 gives the additional data used when using the model for simulation, for calculating effective prices (see section 3.2). Data for parameterising the specialist dairy submodel comes from DG AGRI (FADN). Monetary variables were available in national currencies or converted into national currencies (e.g., direct payments) using relevant exchange rates.

**Table 7.2. Data used for estimation**

Label	Description	Units	Source
$q_1$	beef and veal output	1000 t	SPEL <sup>1</sup>
$q_2$	purchased feed input	1000 t	SPEL
$q_3$	other inputs		SPEL
$p_1$ or $p^b$	price of beef and veal output <sup>3</sup>	n.c. <sup>2</sup> /t	SPEL
$p_2$ or $p^f$	price of feed input <sup>3</sup>	n.c./t	SPEL
$p_3$	price of other inputs	n.c./unit	SPEL
$\Pi$	Restricted profit $= p_1q_1 - p_2q_2$	1000 units of n.c.	calculated
$z_1$	Trend	1973=1, ...	
$z_2$	Land	1000 ha	SPEL
$z_3$	suckler cows	1000 animals	SPEL
$z_4$	dairy cows	1000 animals	SPEL
$z_5$	milk output	1000 t	SPEL
$p_5$	price of milk	n.c./t.	SPEL
$y$	milk yield	1000kg/cow	calculated

1. "SPEL" denotes a Eurostat series, available from the SPEL data base.

2. National currency.

3. Normalised by the price of other inputs,  $p_3$ .

**Table 7.3. Additional data used for simulation**

<b>Description</b>	<b>Units</b>	<b>Series</b>	<b>Source</b>
milk quota ( $\bar{z}_5$ )	1000t	1984-2008	Eurostat
milk premium	Euro/t	2000-2008	OJ
national envelope dairy	Million Euro	2000-2008	OJ
intervention price butter	Euro/t	2000-2008	OJ
intervention price SMP	Euro/t	2000-2008	OJ
farm gate equivalent milk price (IMPE)	Euro/t	2000-2008	OJ
basic price beef	Euro/t	2000-2008	OJ
suckler cow premium	Euro/animal	2000-2008	OJ
additional suckler cow premium	Euro/animal	2000-2008	OJ
special premium bulls	Euro/animal	2000-2008	OJ
special premium steers	Euro/animal	2000-2008	OJ
slaughter premium calves	Euro/animal	2000-2008	OJ
slaughter premium other animals	Euro/animal	2000-2008	OJ
slaughterings of calves, bulls, steers, cows and heifers	1000 animals	1988, 1996, 1999	Eurostat; Dröge (1991)
slaughter weights of calves, bulls, steers, cows and heifers	Kg/animal	1988, 1996, 1999	Eurostat; Dröge (1991)
national envelope beef	Million Euro	2000-2008	OJ
regional ceilings suckler cow premiums, special premiums, slaughter premiums	1000 animals	2000-2008	OJ

### *7.3.5. Estimation and results*

The model consists of two subsystems:

- the short-run restricted profit function (equation (6)) with the associated beef and veal output and feed input functions (equations (7));
- the stock-adjustment model for dairy cow and suckler cow stocks, and the land input (equations (17), (18) and (19)). Disturbance terms are added to account for unobservable deviations of the empirical model from the theoretical model.

The estimation sequence was as follows:

- the stock adjustment subsystem (17), (18) and (19) was estimated as a seemingly unrelated regression system. During the estimation procedure, prior information was used for all coefficients except for the intercepts and the trend coefficients;
- the short-run restricted profit subsystem was estimated using the a set of priors consistent with those used in the stock adjustment model;
- when necessary, the priors were adjusted and the estimation of the subsystems was repeated until the estimates obtained for the same coefficients in both models converge.

By adding the iterative step (step 3) in the estimation procedure, internal theoretical consistency of the empirical subsystems is approximately guaranteed. Estimation was done separately for each EU Member State. Both subsystems were estimated with data for the period 1973-1995 and using the mixed estimation procedure explained in paragraph 7.3.2. In cases where some individual coefficients had extreme values or inappropriate signs, the system was re-estimated using reduced variances on stochastic restrictions on these individual coefficients in order to move the coefficient concerned towards its prior value.

Since the price of beef in the land equation was in nearly all cases not significant and often had a wrong sign, the coefficient was restricted to zero in the finally estimated version of the model.

The goodness-of-fit of the estimation is summarised in Table 7.4.

**Table 7.4. Goodness-of-fit ( $R^2$ ) for the estimated equations**

Equation	B&L	DK	D	GR	E	F	IRL	I	NL	A	P	FIN	S	UK	
Profit function <sup>1</sup>	}	0.77	0.97	0.98	0.97	0.99	0.99	0.97	0.99	0.95	0.97	0.99	0.97	0.96	0.97
Beef and veal supply															
Feed demand															
Dairy cow stock adjustment	0.99	0.95	0.97	0.88	0.79	0.99	0.95	0.95	0.98	0.73	0.71	0.99	0.97	0.97	
Suckler cow stock adjustment	0.99	0.88	0.97	0.77	0.99	0.97	0.98	0.83	0.91	0.64	0.88	0.92	0.94	0.96	
Land adjustment	0.99	0.94	0.58	0.25	0.94	0.98	0.97	0.86	0.92	0.77	0.98	0.86	0.94	0.87	
Number of significant coefficients (out of 71)	57	50	56	38	57	56	45	48	42	41	59	53	56	45	

1.  $R^2$  for the subsystem of three equations.

### *7.3.6. Specialist dairy farm submodel*

In order to analyse the impacts of simulated policy changes at farm level, a representative specialist dairy farm was constructed for each Member State. Using the farm accountancy data sample for 1994, estimates were made of the number of dairy and suckler cows held on the typical specialist dairy farms (farm type 41).<sup>119</sup> It is assumed that the calculated shares for 1994 could also be used for base year 2000.<sup>120</sup> All values are in Euro (constant prices of 2000). Details are given in Table 7.17 of appendix 1. The FADN data was used to estimate the shares of dairy cows and suckler cows kept on specialist dairy farms. The shares of revenue from milk, beef and other enterprises (after deduction of any direct income payments) were also calculated.<sup>121</sup> On the cost side, variable feed costs were deducted from other variables costs, and other variable costs were calculated on a per cow basis.

It is assumed that during the simulation period the shares of total dairy and suckler cows that are held on specialist dairy farms remain constant. The relationship between other revenues and the revenue coming from dairy and beef, and the variable non-feed cost per cow were used to calibrate "other revenue" and "other variable costs" for the base year 2000. Thereafter, it is assumed that "other revenue" remains independent of developments in the beef and dairy enterprises, whereas 25% of other variable non-feed costs also remain independent.<sup>122</sup>

Output from the simulation model is translated into gross margins for specialist dairy farms, using these coefficients. For each simulated scenario, multiplying total simulated dairy and suckler cow numbers for each year in the simulation period, by the specialist dairy farm shares yields the number of dairy cows and suckler cows on the representative specialist dairy farm. There is assumed to be no autonomous growth in the farm size. Therefore, all simulated changes (in gross margins, cow numbers and so on) are due to the simulated policies. This implies that changes in cow numbers on the specialist dairy farm move in parallel with those at aggregate sector level.

Using the number of dairy cows per farm, the average milk yield as simulated, beef & veal yield per animal and prices, milk and beef/veal revenues are calculated. Beef and veal revenues are calculated as

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<sup>119</sup> No data on the number of specialist dairy farms for Austria, Finland and Sweden were available. The number of specialised farms, and the shares of dairy cows and suckler cows hold on specialised farms are estimated to be 40, 0.50, 0.20 (Austria); 25, 0.93, 0.20 (Finland); 16, 0.88, 0.20 (Sweden) respectively.

<sup>120</sup> For the Netherlands, where data for 1999/2000 were available, the shares of various costs were reasonably in line with the FADN 1994 data.

<sup>121</sup> For Finland and Sweden, revenue (and cost) shares of Denmark were used, while for Austria the shares of Portugal were applied.

<sup>122</sup> This is in line with the definition of a specialist dairy farm as having at least two thirds of its standard gross margin coming from dairying.

the revenues from culled (suckler) cows and their offspring. Direct payments as calculated by the simulation model are also included on the revenue side of the calculation. Other variable costs are calculated based on cow numbers, plus an autonomous component as explained above.

Clearly, many simplifying assumptions have been made here. In particular, the assumption that dairy and beef cows on the specialist dairy herd react proportionately with changes in livestock numbers at sector level is debatable. It is arguable that dairy cow numbers on specialist dairy farms are less likely to react to policy changes than on non-specialist farms, whereas suckler cow numbers are likely to react more strongly if specialist dairy farmers perceive keeping specialised beef animals to be a more marginal activity. These assumptions could be tested and possibly made more realistic with the benefit of a detailed study using micro (ideally panel) data. However, it was beyond the scope of this research to attempt such an analysis for all EU Member States.

The purpose of this exercise is to translate the sector level results into estimates of possible changes at the level of identifiable farms. Gross margin, as calculated here for the specialist dairy farm, recognises both other revenue (apart from milk and beef revenue) and other variable costs (as well as feed costs). For the average specialist dairy farm, these other components are less strongly linked, or not at all linked, to milk and beef activities.<sup>123</sup> With some of the more extreme scenarios, these independent sources of revenue will help to dampen changes in gross margins as compared with the sector level calculation, in which gross margin depends only on the two livestock enterprises and feed costs. These two approaches to calculating gross margins, and their interpretations, are discussed in paragraph 7.4.5.

## 7.4. Policy simulations

### 7.4.1. Overview

This section begins by discussing the issue of decoupled payments to farmers, and the reasons why this issue matters in the current trade policy context. Although it is a purely technical question as to whether a policy satisfies the criteria for a decoupled policy measure, it is an empirical question as to whether producers perceive a particular measure to be decoupled and react to it as such. We do not attempt to settle this question here, but rather we explain how the model developed in this research can easily accommodate different degrees of perceived coupledness for the types of direct payments that are becoming increasingly important for the CAP. If a direct payment creates no *perceived* incentive to

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<sup>123</sup> On average, 10-15% of gross revenue is independent of milk and beef in the base period. This is made up of crop output (such as cereals, potatoes), intensive livestock (pigs) and a significant category of non-specified other revenue.

alter production levels, then we consider that the producer does not perceive it as coupled. However, if he perceives it as an incentive to hold more of a productive asset that, in turn, leads to higher production then it is at least partly perceived as coupled.

We also introduce the idea of the "effective price", which describes how the producer *would* calculate his return per unit of output if he perceived direct payments as part of the price he receives for his output. Introducing individual direct payments in a cumulative fashion into the effective price provides a way of incorporating different degrees of coupledness into the price signal received by farmers. By examining changes in effective prices that reflect *all* the Agenda 2000 reform measures, one can assess to what extent the direct payments that were introduced or increased as part of that policy package actually compensate producers for the price cuts.

Two different sets of simulations are reported in this section. Paragraph 7.4.3. looks at the impact of Agenda 2000, under different assumptions about the degree of perceived coupledness of direct payments and autonomous yield growth. Paragraph 7.4.4. reports the simulated impact of Agenda 2000 plus quota abolition in the year 2005. Sensitivity analyses are performed to assess the importance of different assumptions about the gap between the current milk price and the minimum price that farmers would accept to produce at current quota levels (i.e., the "shadow price"). Quota abolition is simulated under two alternative assumptions about price formation: a 25% fall in an exogenously fixed price, and endogenous price formation whereby the price received by milk producers adjusts so as to clear the market for raw milk. In the second case, the internal EU market approaches deregulation. However, this is not a full market liberalisation scenario, as border measures affecting trade remain unchanged.

Both paragraphs 7.4.3 and 7.4.4 begin by explaining how the model was adapted in order to simulate convincingly in these two different policy settings.

In paragraph 7.4.5, some of the main results - already reported at the level of the aggregate beef and dairy producing sector for EU15 - are translated into gross margin changes for specialist dairy farmers in each Member State.

In this section, most results are given at aggregate EU level only. More detailed results for individual countries can be found in appendix 2 (Agenda 2000 with quotas in place) and appendix 3 (Agenda 2000 with quota abolition in 2005).

It is important to recognise that the simulations presented in this section do not have the status of *forecasts* in real time. For example, they do not account for the large loss in production capacity in the United Kingdom in the last two months, due to foot and mouth control measures. Such events mean

that model simulations such as those produced here will always lag behind reality, and be subject to significant forecasting errors. Instead, the simulations presented here should be interpreted as experiments conducted in a "controlled environment" that mimics as realistically as possible the key features of the EU's milk and beef producing sector. The purpose of these experiments is to *compare* different policy alternatives. Assuming that all simulations are similarly affected by any imperfections in the model, the comparative results should still be robust and informative.

#### **7.4.2. Modelling direct payments**

##### **7.4.2.1. The policy issue**

The Agenda 2000 reforms, adopted in March 1999, continue the shift from price support to direct payments that began with the 1992 MacSharry reform. The shift is reinforced for cereals and beef, and introduced for the first time for dairy.

According to the classification of support in the Uruguay Round Agreement on Agriculture, these direct payments are "blue box" payments, i.e., payments linked to current production decisions ("coupled") but in the context of a supply-limiting policy. This last condition is satisfied by the cereals and beef regimes because of the regional ceilings, and by the dairy regime because of the milk quota restrictions. However, the empirical question arises: do producers perceive them as decoupled, and if not, how much difference does it make to their response to the changed policy signals? Decoupling is one of the criteria for a support measure to be eligible for the "green box", which is the category of farm support that is not bound by commitments within the WTO.

The potential impact of the EU's direct payments on agricultural supply depends on the degree to which they are perceived as coupled, as well as on the sensitivity of supply with respect to these payments. To analyse their impact, a two-stage decision making model of farmers behaviour is proposed. In the short run, when farmers choose the optimal variable input mix, they are likely to react largely to market price signals. However, when deciding on land allocation, acreage planted, dairy cow herds, suckler cow herds and other beef animal stocks, direct payments are likely to play a role, because direct payments are in most cases linked to base areas or herd numbers. In this second stage, farmers thus no longer react only to actual prices prevailing in the market, but rather to effective prices, which in addition to market conditions also reflect the impact of the direct payments. Since the quasi-fixed factors (livestock numbers, land areas) are slower to adjust, this two-stage reaction corresponds more or less to the immediate- and medium-run responses. This two-stage framework allows us to investigate the effect of different degrees of perceived coupling.

A second question arises: to what extent do the increased or new "compensatory" payments actually compensate producers for the price reductions in Agenda 2000? In this paragraph, some calculations are performed for the "typical" EU dairy, beef and veal enterprises in order to answer this question.

The impact of direct payments is incorporated into so-called effective prices. These effective prices can then be used to analyse the impact of Agenda 2000 on the EU dairy and beef markets under different assumptions about producers' perceptions of these payments. In point 7.4.2.2, the two-stage decision problem of farmers is presented and the impact of coupled direct payments is illustrated and measured in terms of an effective price signal framework. Point 7.4.2.3. provides the effective dairy price signals under various degrees of assumed coupledness in Agenda 2000. Point 7.4.2.4 calculates the effective price signals relevant for the beef sector.

#### *7.4.2.2. Supply behaviour*

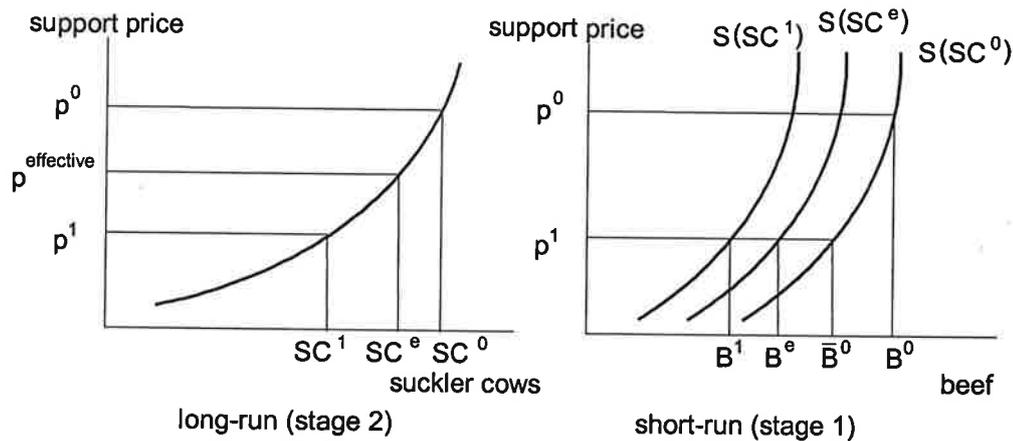
The decision to supply a certain quantity of output can be decomposed into a decision with respect to the optimal level of quasi-fixed inputs used and a decision to determine the optimal mix of variable input used. Figure 7.3 provides a simple graphical illustration with beef production as an example. The output of beef is assumed to depend (among other things) on the price of beef as well as on the (quasi-fixed) suckler cow herd. Now assume the policy maker announces that the beef price will be reduced, but that the farmer's income loss will be partly compensated by a suckler cow premium. The beef price decline from  $p^0$  to  $p^1$  can be decomposed into two effects. It induces a change in the variable input mix for a given suckler cow herd and it also leads to an adjustment of the suckler cow herd. Algebraically, the change in beef supply due to a beef price change may be written as:

$$\frac{dB}{dp} = \frac{\partial B}{\partial p} + \frac{\partial B}{\partial SC} \frac{\partial SC}{\partial p} \quad (45)$$

with the first right hand side term the direct effect and the second term the indirect effect.

If the compensatory direct payment were decoupled, both the suckler cow herd and the variable input mix would be adjusted based on the same beef price signal. The suckler cow herd would decline from  $SC^0$  to  $SC^1$  and beef supply from  $B^0$  to  $B^1$ . If a change in the suckler cow herd has any consequences whatsoever for the number of suckler cow premiums a farmer receives, the direct payment is coupled. In the case shown in Figure 7.3, the payment is coupled since it results in a supply of  $B^e$  rather than  $B^1$ , and therefore has an effect on production.

**Figure 7.3. The farmer's two-stage decision process**



In deciding on the suckler cow herd, the farmer then not only takes the announced beef price decline into account, but also the direct payments associated with the suckler cow herd level. Assume that when taking this into account, the farmer reduces his suckler cow herd from  $SC^0$  to  $SC^e$  instead of to  $SC^1$ . The price signal supporting this suckler cow herd level is the effective price level  $p^{effective}$ , which clearly differs from the prevailing market price  $p^1$ .

As is shown in equation (45), the impact of a suckler cow herd change on beef output depends also on the partial derivative  $\partial B / \partial SC$ , which is dependent on the production technology. If there is a direct fixed relationship between the quasi-fixed input (suckler cows) and beef output, the effective price reasoning could be directly applied to the short-run supply equation. Examples of this latter case are land allocation with fixed crop yields (see Houck et al, 1976) and dairy cow herd size with fixed milk yields. If, however, the production technology allows for substitution (for example, between beef-producing dairy cows and suckler cows), the effective price reasoning should be applied to the cow herd equations only and not to the short-run supply relationships.

The difference between the announced market price for beef  $p^1$  and the effective beef price depends on the size of the direct payments as well as the degree to which farmers perceive them as coupled. Although from a theoretical perspective direct payments are coupled as long as there is a link with a current factor of production, what finally matters is whether the farmer as decision maker perceives them as coupled. In other words, does the producer supply  $B^e$  rather than  $B^1$ ? The EU's direct payments are usually subject to regional ceilings based on past reference areas, production levels or

herd numbers. However, an individual farmer is only eligible for the direct payment if he currently uses the inputs associated with these payments, and thus his stocking levels and hence current production may well be influenced.

In the following points, effective prices are calculated for the Agenda 2000 policy changes in the dairy and beef sectors. Because beef originates from several different enterprises, different farming practices will be distinguished.

#### *7.4.2.3. Policy changes regarding dairy*

The Agenda 2000 decision of 21 March includes the following measures with respect to the dairy sector (see Regulations EC1255/99 and EC1256/99):

- a 15% price cut for intervention butter and skimmed milk powder (SMP), introduced in three equal steps over the marketing years 2005/06-2007/08;
- a quota increase of 2.4%, of which part takes effect in 2000, whilst the rest is granted parallel with the price reductions;
- a new milk premium increasing from 5.75 Euro/ton in (calendar year) 2005 to 17.24 Euro/ton in 2008;
- a national envelope to make additional payments, either per unit of milk, or per hectare;
- extension of the dairy quota system till 2008.

The calculation of effective prices for dairy can focus directly on milk output since there are no compensatory payments linked to dairy cows. A complication, however, is that the price of raw milk at farm gate level is derived from the prices for milk products. As is indicated above, the intervention price cuts for butter and skim milk powder are partly compensated for by an increase in the dairy quota and a system of direct aids, which, however, will be excluded from the effective price calculation. Producers will qualify for the dairy premium, which is granted per holding and per ton of original individual reference quantity (additional quota granted is not part of the base for receiving a dairy premium). As a top-up to this, additional money is allocated to dairy by direct payments through national envelopes.

Different effective price reductions perceived by farmers imply different degrees of coupling. Table 7.5 gives an indication of the consequences of the dairy policy change expressed in terms of (effective) milk price reductions. The first three rows give the changes in the institutional prices (target and intervention prices for butter and skimmed milk powder, SMP). Because the market is

characterised by excess supply, instead of the target price, a derived price based on intervention prices is used as a proxy of the price relevant to the primary sector. This price, the so-called intervention milk price equivalent (IMPE) is calculated according to a standard formula (see EU Dairy Facts and Figures, Tables 5 and 6 for the way of computation).<sup>124</sup>

**Table 7.5. Calculated effective milk price reductions (Euro/t)**

	2000-2004	2005	2006	2007	2008	% change 2008/2000
"target milk price"	309.80	292.30	274.70	257.20	257.20	-17.0
Butter (intervention price)	3282.00	3117.00	2953.80	2789.70	2789.70	-15.0
SMP (intervention price)	2055.20	1952.40	1849.70	1746.90	1746.90	-15.0
IMPE(1) (based on milk intervention)	284.14	268.28	252.42	236.56	236.56	-16.7
EU financed milk premium	0.00	5.75	11.49	17.24	17.24	
IMPE(2) = IMP(1) + milk premium	284.14	274.03	266.44	258.92	261.10	-10.7
Nat. Envelope 'milk premium'	0.00	5.75	11.49	17.24	17.24	
IMPE(3) = IMPE(2) + nat. envelope	284.14	274.03	266.44	258.92	261.10	-8.1
Max. allowed milk premium	0.00	13.90	27.80	41.70	41.70	
IMPE(4)='max. allowed compensation'	284.14	282.18	280.22	278.26	278.26	-2.1

The calculated IMPE will decline by approximately 17%. This is the relevant price decline if farmers perceive all compensating payments as completely decoupled. However, so far, all compensatory payments are disregarded. If producers perceive the EU-financed milk premiums (attached to the quota reference levels) to be coupled, the (effective) raw milk price reduction (again expressed in IMPE terms) is only 11% (Table 7.5, row 6). Moreover, if the national envelope funds are fully paid as an additional milk premium (paid on all milk), the effective price decline would be about 8% (see Table 7.5, row 9). Countries are free to spend the national envelope funds in various ways, e.g., as payments per hectare and/or as payments to farmers with specific characteristics. However, even if countries decide to concentrate these payments on a small group of targeted farmers, in no case should the amount paid (expressed per unit of milk) exceed the maximum allowed milk premium specified by the Commission. The minimum effective raw milk price reduction, therefore, cannot be less than 2% (see Table 7.5, row 10, IMPE(4)).

<sup>124</sup> For butter 90% of the indicated intervention price was used. Processing margins are estimated at 255 Euro/t and 240 Euro/t for butter and powder respectively.

The calculations presented in Table 7.5 show that, starting from a price cut of 15% in intervention prices for both butter and skim milk powder, the effective price reduction could be only 8%, depending on the extent to which producers perceive the accompanying direct payments to be coupled, and how these payments are actually made. Indeed, if national envelope funds are paid to a sub group of dairy farmers at the maximum allowable rate, *for these farmers* the effective price decrease would be as little as 2%.

#### 7.4.2.4. Policy changes regarding beef and veal

With respect to beef and veal, Agenda 2000 specifies (see Regulation EC1254/99):

- a beef price decline of 20% in two equal steps over the calendar year period 2000 to 2002;
- increased headage payments (suckler cow premium of 200 Euro, special premium of 210 (150) for bulls (steers), and slaughter premium of 80 (50) Euro for adult animals (calves));
- a national envelope to make additional payments, payable per head and/or per hectare.

Over the period 2000-2002, the basic beef price (equal to 80% of the intervention price and trigger level for intervention) is decreased by 20% (see Table 7.6). The regime of compensatory direct payments consists of a special premium for male bovine animals (bulls and steers), a suckler cow premium, and a slaughter premium (differentiated for calves between 1-7 months and other animals from the age of 8 months). In addition to the suckler cow premium presented in Table 7.6, Member States may grant an additional suckler cow premium up to a maximum of 50 Euro per animal. This premium is partly financed (24.15 Euro) by the EAGGF's Guarantee Section if the holdings are located in specific areas, or completely financed if the share of suckler cows in a Member State's cattle is at least 30%, and if at least 30% of its male bovine animals slaughtered belong to conformation classes S and E.<sup>125</sup>

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<sup>125</sup> Assuming the male meat quality requirement is satisfied, according to the suckler cow share criterion and our 1999 estimates Belgium, Greece, Spain, France, Ireland, Luxembourg, Portugal and the UK would qualify for completely financed premiums. It is uncertain whether the other Member States which have to finance the premium by themselves will decide to grant this additional premium, and for what amount.

**Table 7.6. Beef prices (Euro/ton) and direct payments (Euro/animal)**

	1999	2000	2001	2002-2008	% change 2002/1999
"basic price" (Euro/ton)	2780	2595	2409	2224	- 20
special premium (bull)	136	160	185	210	+ 84
special premium (steer)	109	122	136	150	+ 41
suckler cow premium	145	163	182	200	+ 55
additional suckler cow premium	0	50	50	50	+ 50
slaughter premium calves	16	17	33	50	+ 34
slaughter premium others	27	27	53	80	+ 53

Moreover, there was already a deseasonalisation premium (unchanged), aimed at encouraging farmers who have steers to hold them through the winter months (mainly of interest to Ireland and the UK (Northern Ireland)). Besides, producers receiving the special and/or suckler cow premium may qualify for an extensification payment, provided they satisfy the relevant stocking density criteria (an additional 100 Euro per special premium and suckler cow premium, given that the stocking density on the holding concerned is less than or equal to 1.4 livestock units). In this analysis, the extensification payments are neglected because our focus is on market level or average representative farm level rather than at individual farm level. The headage premiums are subject to a number of restrictions, notably regional ceilings.

Since the slaughter premium ceilings are based on year 1995 and production has declined since then, the corresponding regional ceiling is not likely to be binding. Regarding bulls and bullocks, the average EU herd of male animals aged less than 1 year over the period 1996-1999 was 9.38 million animals and showed a decrease of 4.4 per cent per annum. The average herd of male animals aged between 1 and 2 years was 6.87 million animals and showed a 2.1% annual decline. The total number of male animals eligible for the special premium is 9.28 million animals. Conditional on the ceiling, the premium is granted once in the life of a bull from the age of 9 months, or twice in the life of a steer (first at the age of 9 months and then at the age of 21 months). It is assumed, therefore, that on average the special premium can be received 1.25 times during an animal's lifetime.<sup>126</sup> Given the male animals older than 1 year, the number of premiums can then be estimated as 1.25 times 6.87, which is 8.6 million, while there still remains 0.68 million premiums available for the cohort aged between 9

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<sup>126</sup> Based on the estimated bull/bullock herd composition, which suggests that about 25% of the herd is eligible to receive the special premium twice in its lifetime.

and 12 months. Given a normal age structure this is a low number. In other words, the current herds appear to have the potential to overshoot the ceiling for special premiums.

The share of the total EU beef and veal output coming from bulls and bullocks varies between 45% and 50% of total EU beef and veal output. Cows and heifers account for another 40%, while the share of calves is about 11% (see Table 7.18, appendix 1). These shares are rather stable over time. In terms of number of slaughtered animals, the share of dairy cows in the total number of cows slaughtered is estimated at 75%. This is mainly due to differences in average lifetime of animals in dairy and suckler cow herds. The average life of a dairy cow is estimated to be 4-5 years, and that of suckler cows at 5-7 years. Dairy cow culling is mainly based on optimal dairying considerations (aimed at low costs of milk) and less or not at all on meat producing considerations. Because suckler cows have a higher slaughter weight than dairy cows, the share in final cow meat production of suckler cows will be higher than 25%.

In order to estimate the effective price decline resulting from the beef and veal policy adjustments, some calculations have been made for suckler cow holdings and bull and bullock operations. Table 7.7 presents the policy impact per suckler cow under various assumed degrees of perceived coupling. First, it is assumed that the intervention price decline of 20% leads to an equivalent decline in the farm gate price of meat.<sup>127</sup> The implicit technical coefficients (like number of calves raised per cow, number of heifers kept per cow, assumed slaughter weights, replacement rate) of the typical suckler cow operation presented in Table 7.7, are own estimates based on Heinrich and Kögl (1992). The prices are plausible values selected from actual realisations in recent years (cf. for example Table 4.15.5.1 of European Commission, 1999). In the calculations, a premium utilisation rate of 100 per cent of the regional ceiling is assumed. Table 7.7 measures the effective price change in two ways: a) as measured in (direct) revenue terms and b) also when accounting for related animal input cost changes. It considers four alternatives with increasing degrees of perceived coupling (see columns of Table 7.8). The following eight alternatives resulted:

- 1) The impact when only the increased slaughter premiums are perceived as coupled: effective price changes are -14.1% and -12.5% respectively.
- 2) Same as 1) but also allowing for the increased (general) suckler cow premium: effective price changes are -9.1% and -7.1% respectively.
- 3) Same as 2) but now including the additional suckler cow premium Member States are allowed to grant: effective price changes are -3.1% and -0.6% respectively.

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<sup>127</sup> This is a minimum estimate. Given a non-zero fixed processing margin, the price decline at farm gate level would be greater.

4) Same as 3) but including the additional payments coming from the national envelope funds<sup>128</sup>: effective price changes are -0.8% and +1.9% respectively.

Table 7.7 does not present a gross margin analysis, because it excludes non-animal input costs. So it does not take into account the feed cost price decline expected following the 15% fall in cereal intervention prices. In our simulations, the model would take the feed price adjustment directly into account, rather than incorporate it into an effective output price.

The impact of the Agenda 2000 policy change on bull and bullock operations is illustrated in Table 7.8. The calculation scheme is again based on Heinrich and Kögl (1992), and takes into account fattening practices in Germany, France and Ireland. A premium utilisation rate of 80% is used. It is assumed that on average the special premium can be received 1.25 times during an animal's lifetime. Likewise in Table 7.7 again the effective price changes are calculated in terms of the change in meat revenue, and in terms of changed meat revenue corrected for expected changes in related animal input costs. Table 7.8 shows the impact of the policy change on bull and bullock operations under four different assumptions. First only the slaughter premium is perceived as coupled, to which subsequently the special premiums and the national envelope payments are added. The national envelope payment per kilogram is the same as for suckler cows (6 Euro/100kg). This resulted in the following alternatives:

- 1) The signals when only slaughter premiums are accounted for: effective price changes are -15.8 and -14.8 respectively.
- 2) Same as 1) but including the change in special premium: effective price changes are -9.7% and -7.4% respectively.
- 3) Same as 2) but including the additional payments coming from the national envelope funds<sup>129</sup>: effective price changes are -7.9% and -5.2% respectively.

The calculated effective price changes do not yet take into account changes in other input costs. If it is assumed that the animals are fed with home-grown silage maize, supplemented with compound feed (a usual practice), and assuming a constant calf grow-up cost of Euro 94, the effective revenue decline (measured in gross margin terms) would be -18%, -5.4% and -1.7% for scenarios 1, 2, and 3 respectively.

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<sup>128</sup> Expressing the national envelope funds in terms of an amount per kilogram of meat yields an amount of roughly 6 Euro/100kg.

<sup>129</sup> As before a national envelope payment of 6 Euro/100kg meat is assumed.

Comparing Tables 7.7 and 7.8 shows that the effective price declines for suckler cows and bulls are approximately of the same order in the case where only slaughter premiums are accounted for or if, in addition to this, the standard suckler cow premium and special premium are accounted for. Combined, the additional suckler cow premium Member States may grant to suckler cow operations and the national envelope payments lead to nearly full compensation of the meat output price decline. With respect to bulls, even when national envelope payments are taken into account, compensation is only partial. However, bull/bullock operations are relatively more reliant on non-grass feed input. Taking the approximated feed input cost change into account, more than 90% of the meat price decline is compensated (measured in gross margin terms). In the following, the over-all average effective price changes in specialised meat production are approximated by a weighted average of the computed effective price declines for suckler cows and bulls/bullocks. Country-specific shares were used to measure the relative importance in specialised meat production of suckler cows and bulls/bullocks.

Similar calculations have also been done for calves (not shown here). When feed cost changes are taken into account, as well as output price reductions and direct payment increases, there is a very small increase in gross margin.

This paragraph has shown that, for the typical dairy or beef producer, the falls in *effective* price resulting from the Agenda 2000 reforms may be much smaller than the announced price reductions if the direct payments are perceived as coupled to output or to livestock numbers. The question then arises: how much difference does it make to outcomes? In our simulations we perform sensitivity analyses to answer this question. Moreover, whether or not the direct payments are perceived as having a production incentive, it is clear that they go some way, but not the whole distance, towards compensating producers for the Agenda 2000 price cuts.

**Table 7.7. Policy impacts per suckler cow under various assumptions**

	quantities	before		without additional payments			+national s.c.premium			+ nat. envelope payments		
		Euro	Euro/s.c.	Euro/100kg	Euro	% change	Euro/100kg	Euro	% change	Euro/100kg	Euro	% change
<b>Herdsize (1 suckler cow)</b>	1.00											
Premium utilization rate	1.00											
<b>Output</b>												
member state s.c. premium	1.19						50.0	59.38		50.0	59.38	
national envelope											23.00	
'calves' (330 kg)	0.95	280.0	877.80	224.0	702.24	-20.0	224.0	702.24	-20.0	224.0	702.24	-20.0
slaughter premium	0.95	0.0	0.00	53.0	50.35		53.0	50.35		53.0	50.35	
suckler cow premium	1.00	0.0	0.00	50.0	50.00		50.0	50.00		50.0	50.00	
culled cows (330 kg)	0.16	220.0	117.98	176.0	94.38	-20.0	176.0	94.38	-20.0	176.0	94.38	-20.0
slaughter premium	0.16	0.0	0.00	53.0	8.61		53.0	8.61		53.0	8.61	
			995.78		905.58	-9.1		964.96	-3.1		987.96	-0.8
<b>Input</b>												
heifers	0.19	410.0	76.88	328.0	61.50	-20.0	328.0	61.50	-20.0	328.0	61.50	-20.0
suckler cow premium	0.19	0.0	0.00	50.0	-9.38		50.0	-9.38		50.0	-9.38	
calves	0.05	85.0	4.25	68.0	3.40	-20.0	68.0	3.40	-20.0	68.0	3.40	-20.0
			81.13		55.53	-31.6		55.53	-31.6		55.53	-31.6
			914.65		850.06	-7.1		909.43	-0.6		932.43	1.9

Prices are in Euro/100kg or Euro/animal (all premiums, input costs); Premiums are measured in terms of changes w.r.t. base year 1999.

**Table 7.8. Policy signals per bull/bullock under various assumptions**

	before			only including sl. premium			+ special premium			+ national envelope payments		
	quantities	prices	value	prices	value	% change	prices	value	% change	prices	value	% change
<b>Herd (1 bull/bullock)</b>	1											
Spec.premium utiliz. rate	0.8											
<b>Output revenue</b>												
National envelope payments											21.75	
bull (625kg lw;362.5kg sw)	0.99	2.0	1231.25	1.6	985.00	-20.00	1.6	985.00	-20.00	1.6	985.00	-20.00
slaughter subsidies	0.99	0.0	0.00	53.0	52.21		53.0	52.21		53.0	52.21	
special premium	1.00	0.0	0.00		0.00		75.0	75.00		75.0	75.00	
Revenue			1231.25		1037.21	-15.76		1112.21	-9.67		1133.96	-7.90
<b>Input costs</b>												
calves (45 kg)	1.00	5.0	225.00	4.0	180.00	-20.00	4.0	180.00	-20.00	4.0	180.00	-20.00
Net revenue			1006.25		857.21	-14.81		932.21	-7.36		953.96	-5.20

Prices in Euro (animal prices in Euro/kg liveweight); Premiums are measured in terms of changes w.r.t. base year 1999.

### 7.4.3. Simulations: Agenda 2000

#### 7.4.3.1. Background

This paragraph analyses the policy impacts of Agenda 2000 on the EU's dairy/beef sector over the period 2000-2010, on the assumption that quotas are maintained over the whole simulation horizon. Agenda 2000 lowers intervention prices for butter and skimmed milk powder by 15%, beef support price by 20%, and cereals intervention prices by 15%. These reductions in price support are compensated by a system of direct payments. Critical issues to be analysed are to what extent the impact of the price changes is reduced if producers perceive the compensatory direct payments as coupled, how much producers gain from the concurrent reductions in feed price and whether autonomous yield growth improves or worsens producers' income situation within this policy context. Sensitivity analysis is performed with respect to the degree with which farmers perceive direct payments as coupled, and for two rates of autonomous dairy yield growth.

As described in the previous paragraph, farmers' decision-making has a two-stage structure. First, farmers decide how much beef and veal output (and milk output if quotas are not binding) to produce and how much feed to use, given prices actually prevailing in the market. Given these decisions, they then decide how many dairy cows and suckler cows they are going to hold and how much land (grazing and forage area) they will use. Since direct payments are linked to (suckler) cow numbers, it is assumed that they will at least partly take the direct payments into account in the second-stage (stocking) decisions. Stock adjustment takes more than one period to complete.

Assuming typical suckler cow, calf fattening and beef fattening operations, an assessment was made in the previous paragraph of the impact of the various premiums (slaughter premium, suckler cow premium, male premium) and national envelopes on the effective prices *if farmers perceive those premiums as coupled*. A summary table, indicating the effective price declines associated with different degrees of perceived coupledness is given below. Table 7.9 suggests that when beef producers perceive all direct payments (including the national envelopes) to be coupled, they perceive the effective beef price decline as only 2.26% instead of the 20% announced in Agenda 2000.

The "correction for non-feed costs" reflects the change in effective price if the change in animal input costs of beef and veal production are taken into account. When the output price of beef falls, the cost of buying a replacement calf is also assumed to be lower.

**Table 7.9. Calculated effective price reductions (% of original price)**

<b>Direct payments perceived as coupled (cumulative)</b>	<b>Effective price reduction %</b>
Beef and veal	
<b>Slaughter premiums on all animals</b>	-14.86
<b>Suckler cow premiums and special premiums</b>	-7.25
<b>National envelope beef</b>	-5.17
<b>Corrected non-feed costs</b>	-2.26
Dairy	
<b>Agenda 200 milk price at farm gate level</b>	-16.75
<b>Milk premium</b>	-10.68
<b>National envelope dairy</b>	-8.11

The information shown in Table 7.9 is given at Member State level in Table 7.19, appendix 1. The variations in the effective beef and veal price over Member States are due to differences in their beef output composition (relative proportions of beef from suckler and dairy herds). The effective milk price changes are derived from official EU butter and SMP intervention prices and are expressed in terms of standardised milk. Therefore they show no variation over Member States. In the simulations, intervention price changes are linearly linked to actual farm gate prices. Regional differences in farm gate prices for milk and beef are accounted for by a fixed margin.

The simulation model used in this paragraph consists of the equations as described in Table 7.1, section 7.2. The model is calibrated to the base year 2000 and simulations reported here are done for the period 2000-2010. When quotas are in force, milk supply is given simply as:

$$z_5 = z_5^{quota} \quad (46)$$

The stock adjustment equations for suckler cows and land are as given in equations (17) and (18). However, the adjustment equation for dairy cows follows a simpler reaction path than the one specified in equation (19). This is because, with milk output constrained by quota, and a rather inflexible relationship between milk output and dairy cows, farmers have little room for manoeuvre in adjusting their dairy cow stock. Under quotas, dairy cow adjustment is given by:

$$z_{4,t} = \lambda_4 \left( \frac{z_5^{quota}}{y} \right)_{t-1} + (1 - \lambda_4) z_{4,t-1} \quad (47)$$

In all simulations in this and the following paragraph, if countries have rigid environmental constraints (like the Netherlands) then an additional environmental stocking density constraint restricting the intensity of dairying might become binding:

$$z_{4,t}^{\max} = s^{\max} \cdot z_{2,t} - z_{3,t} \quad (48)$$

where  $s^{\max}$  represents the maximum stocking density, and with the final number of dairy cows equal to  $\min(z_{4,t}, z_{4,t}^{\max})$ .

To impose exogenous yield growth (rate  $g$ ), equation (47) is reformulated as:

$$z_{4,t} = \lambda_4 \left( \frac{z_5^{\text{quota}}}{y} \right)_{t-1} \times \frac{1}{1+g} + (1-\lambda_4)z_{4,t-1} \quad (49)$$

The accounting equations in the model determine gross margins, numbers of animals slaughtered, direct payments (including national envelopes), and aggregate quantities at EU level. Moreover, a module is added to translate changes in aggregate variables to specialised dairy farms.

#### 7.4.3.2. Agenda 2000 scenarios

The simulations depict the post-Agenda 2000 situation, with quotas maintained. The Agenda 2000 price reductions are phased in over three years as stipulated by the regulation. Sensitivity analysis with respect to yield growth and feed price is performed. Some scenarios also explore the differences in outcome depending on the degree to which direct payments are perceived as decoupled. If a direct payment is perceived as coupled, the *effective* price decline instead of the announced output price decline is used as the price signal in the stock adjustment equations (17) and (18).

Three scenarios simulate Agenda 2000 with all direct payments perceived as decoupled:

- S10: Decoupled-scenario: beef price -20%; milk price -15%; feed price -15%, no yield growth, direct payments and national envelopes as planned;
- S10y: As scenario S10, but with 1.3% p.a. yield milk yield growth<sup>130</sup>;
- S10f: As S10 but with feed price -7.5% instead of -15%.

A further group of scenarios considers the issue of coupling/decoupling. The scenarios differ with respect to how far farmers perceive the direct premiums as coupled. In terms of the simulation model this implies that different effective price signals (associated with different degrees of perceived coupling) are fed into the stock adjustment model. The scenarios are conditional on a 15% feed price decline and zero autonomous milk yield. Beef price and milk prices (relevant for the beef & veal

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<sup>130</sup> The assumed milk yield growth is based on analysing long term trends in the EU and corresponds with the yield growth assumed in the WATSIM trade policy simulations (see chapter 5).

output and variable feed input equations) are as planned in Agenda 2000 (price of beef -20%, price of milk -15%). Since quotas are assumed to be binding there is no need to consider whether milk premiums are perceived as coupled or not.

Four scenarios simulate Agenda 2000 with only some or all direct payments perceived as coupled:

- S11.1: Only slaughter premiums perceived as decoupled;
- S11.2: Slaughter premiums, suckler premiums<sup>131</sup>, and special premiums perceived as coupled;
- S11.3: Same as scenario S11.2, but now also with the national envelopes perceived as coupled;
- S11.4: Same as S11.3, but now also taking the (induced) changes in non-feed input costs into account.

#### *7.4.3.3. Simulation results: Agenda 2000*

The simulation results are shown in Table 7.10. Tables with simulation results at Member State level are provided in appendix 2.

Most rows in the table are self-explanatory. The gross margin variable shown in the last rows is calculated as total revenues from milk production and beef production (from both the beef and dairy enterprises), plus direct payments to both milk and beef, less feed costs. It could more properly be called "margin over feed cost" and should not be interpreted as a whole-farm gross margin, still less as an indicator of net income.

Due to the quota and the fixed yield relationship (see equation (47)) the dairy cow stock behaves the same in all scenarios except S10y, in which a milk yield growth of 1.3% p.a. was assumed. In scenario S10y, the dairy cow stock is 12 percentage points lower than in scenario S10. The yield growth assumption has also a significant impact on the suckler cow stock due to suckler/dairy cow competition. In scenario S10y, the suckler cow stock is 17.5 percentage points higher than in the standard case S10. Looking at feed consumption, it appears that in scenario S10y the impact of lower dairy cow numbers is dominant. Feed demand in scenario S10y is lowest, in spite of the same milk output and the increased number of suckler cows as compared to scenario S10. As scenario S10f shows, halving the feed price decline (from -15% to -7.5%) also halves the feed consumption increase as compared with S10.

The sensitivity analysis regarding decoupling shows that the suckler cow stock increases with the degree to which farmers perceive the direct payments as coupled. In the most extreme case (scenario

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<sup>131</sup> Includes so-called additional suckler cow premium.

S11.4 with all direct payments including national envelopes perceived as coupled), the suckler cow stock is about 12 percentage points higher than in the decoupled scenario S10. In scenario S11.4, however, total beef output has still declined (-2.9%) by 2010 as compared with the base year. When comparing scenarios S11.4 (showing the impact of beef price decline on suckler cow numbers and the associated impact on meat production) and S10y (showing the impact of dairy cow decline on meat production), it becomes evident that the contribution of the dairy stock to total beef output in the EU is very important. A given percentage decline in dairy cow numbers results in a greater impact on beef production than the same percentage decline in suckler cow numbers.

When comparing net revenues in 2010 with base year 2000, it appears that the compensation falls short by about 7-8% in all scenarios, without a large difference over the scenarios. In the scenario where the maximum extent of perceived coupling is assumed, the fall in net revenues is about 2.5 percentage points less than in the standard scenario S10.

**Table 7.10. Summary simulation results (at EU level)**

Variable	year	Scenario			Scenario			
		S10	S10y	S10f	S11.1	S11.2	S11.3	S11.4
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	101.2	96.6	101.2	101.2	101.2	101.2	101.2
	2008	102.3	92.7	102.3	102.3	102.3	102.3	102.3
	2010	102.4	90.4	102.4	102.4	102.4	102.4	102.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	88.1	93.2	89.0	90.6	94.2	95.2	96.6
	2008	83.4	96.8	84.5	86.4	91.1	92.3	94.1
	2010	82.5	100.2	83.2	85.8	90.8	92.1	93.9
q milk	2000	100.6	100.6	100.6	100.6	100.6	100.6	100.6
	2004	101.2	101.2	101.2	101.2	101.2	101.2	101.2
	2008	102.4	102.4	102.4	102.4	102.4	102.4	102.4
	2010	102.4	102.4	102.4	102.4	102.4	102.4	102.4
q beef & veal	2000	99.5	99.5	99.4	99.5	99.5	99.5	99.5
	2004	95.2	93.2	95.2	95.9	97.1	97.4	97.8
	2008	93.3	90.9	93.7	94.4	96.2	96.6	97.3
	2010	92.8	90.4	93.1	94.1	95.9	96.4	97.1
q feed	2000	103.0	103.0	101.7	103.0	103.0	103.0	103.0
	2004	105.3	102.6	102.4	105.5	105.9	106.0	106.2
	2008	106.1	101.2	103.2	106.4	106.8	107.0	107.2
	2010	106.1	100.2	103.2	106.4	106.9	107.0	107.2
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.0	98.5	99.4	99.1	99.2	99.2	99.3
	2008	98.3	96.9	98.9	98.5	98.8	98.9	99.0
	2010	98.2	96.2	98.8	98.4	98.8	98.9	99.0
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	97.6	97.4	98.3	99.0	99.1	99.4
	2008	92.2	92.4	91.7	92.8	93.7	93.9	94.3
	2010	91.9	92.8	91.3	92.4	93.2	93.4	93.7

#### 7.4.4. Simulations: Agenda 2000 plus quota abolition

##### 7.4.4.1. Background

The model used for simulating the quota abolition scenarios is summarised in the last column of Table 7.1 in section 7.2. Unlike the model used in the previous paragraph, after quota abolition, milk supply adjusts according to the shadow milk supply function, given by:

$$z_s = -\frac{1}{\beta_{55}} (p_5^s + \beta_5 + \sum_{k=1}^4 \beta_{k5} z_k + \sum_{i=1}^2 \gamma_{i5} p_i) \quad (50)$$

As extensively discussed in section 7.3, the immediate short-run response of milk supply to milk price as given in this equation, given the levels of the quasi-fixed factors, is quite small. However, after one period, as the cow numbers begin to adjust there is greater responsiveness of milk supply. The full response extends over a number of periods, and depends also on prices for beef and feed.

Figure 7.4 shows a stylised picture of the market for milk under the quota regime. The underlying shadow price function for milk depends on the dairy technology and the structure of the sector. It shows how the marginal cost of supplying milk increases as the level of aggregate supply increases. When a quota regime is in place, the quantity supplied no longer depends on the signal given by price. As long as quota is binding, output is determined by the quota limit, and price is given independently. Therefore, the particular combination of  $p_0^0$  and  $q_0^0$  that is observed no longer represents a point on the supply curve. It is for this reason that, once quotas have been in place for some years, it is impossible to estimate directly from observed price and quantity outcomes either the slope or the height of the shadow milk supply function.

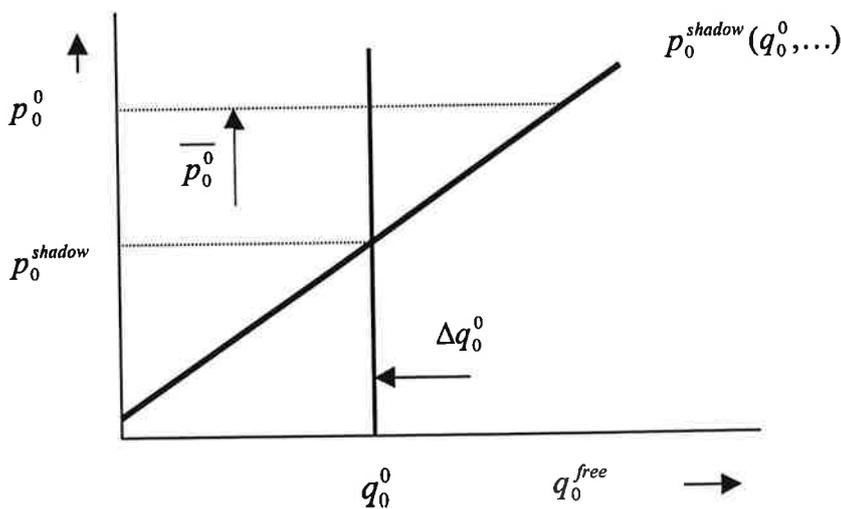
Our method for deriving the shadow milk supply function from the profit function gives reasonably reliable information about the slope of the function, which is important for assessing changes in output, in the post-quota environment, as price fluctuates. However, this method is considered less reliable as regards fixing the height of the function at the quota level. This information is, however, especially important for accurately predicting the extent of the first adjustments after quota abolition, and the level of price that would be reached in the post-quota milk market if no intervention measures are in place.

The difference between the price  $p_0^0$  and the shadow price at quota level,  $p_0^{shadow}$ , shown in Figure 7.4, is known as the quota rent. Information about the quota rent is needed to fix the position of the shadow milk response function at the marginal point. Theoretically, the quota rent is the maximum amount that the marginal producer (producer of the litre with the highest marginal cost) would be willing to pay to purchase additional quota. Clearly, information from quota markets (purchase or

lease markets) would be useful in order to estimate the quota rent empirically. Now, the marginal producer is unlikely to be a purchaser of quota. If he sells his quota, then the quota rent represents (theoretically) the minimum price for which he would be willing to sell. Quota purchasers are likely to be intra-marginal producers whose quota rent is larger than that of the marginal producer. According to this argument, quota rents as estimated by prices in quota markets may over-state the quota rent at the marginal point.

Figure 7.4 gives the impression that there would be no expansion in supply if the post-quota market price for milk happened to be equal to  $p_0^{shadow}$ . This reasoning is in fact misleading. After years of quotas, not all producers are producing at this same marginal cost, due to quota constraints on individual producers. The rigidities of the quota scheme mean, especially in countries where the scope for quota transfer is limited, that there could be a wide dispersion of shadow milk price amongst individual dairy producers within the same country. Many producers have succeeded in lowering their costs significantly over the years but without matching their improved performance with acquisitions of extra quota, which would force them to move along their marginal cost curves to a higher level. For these producers, their marginal cost at their current quota level is well below  $p_0^{shadow}$ . Therefore, if quotas were abolished and the price  $p_0^{shadow}$  were imposed, these lower cost producers would still have an incentive to expand from their current quota levels. If this puts downward pressure on price, producers who are "marginal" at  $p_0^{shadow}$  would cease production. This would lower the position of the shadow milk supply function over the relevant output range.

**Figure 7.4. The shadow price of milk and the milk quota**



Therefore, uncertainty about the shadow milk supply function can be characterised under different headings:

- uncertainty about the responsiveness to price changes (slope of the function);
- uncertainty about the height of the function;
- uncertainty about changes in the height and slope of the function that would occur, after quota abolition, due to producers' adjustments and re-structuring of dairy farming.

As already stated, we consider that our method gives reasonably reliable estimates of the slope of the shadow supply function for the with-quota period. Regarding the current height of the function, we have used country-specific information on quota prices (where available<sup>132</sup>), plus other information (on herd size structure, production costs on specialist dairy farms, length of time quotas have been in operation, the severity with which quotas have been applied) to make some crude subjective estimates of each Member State's quota rent, as a percentage of the current milk price. These estimates were formulated as follows. It was assumed that the (unweighted) average shadow price for milk in the EU is currently 70% of the milk price. The distribution of individual countries milk shadow prices around the EU average was then fixed, based on available information. However, these estimates have been subjected to a sensitivity analysis, in order to investigate how important they are in determining the simulation outcomes. These estimates are shown in the second line for each country in Table 7.11. In order to carry out sensitivity analyses, the average EU percentage was varied by 10 percentage points above and below 70% (to 80% and 60%) and the levels in Member States were varied proportionately to maintain the relative differentials between individual Member States and the EU average. Therefore, in all three lines of the table, it is assumed that the shadow price of milk is about 22%, 25% and 14% below the EU average in France, the Netherlands and the UK respectively, and about 17% above the EU average in Greece and Portugal. In all other Member States, the shadow milk price is assumed to lie within 12% or less of the EU average. Clearly, these assumed differentials are quite large and need further refinement.

A number of preliminary sensitivity analyses embodying various other assumptions were performed, and the results were analysed. In this report, we show results based on the three alternatives given in Table 7.11.

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<sup>132</sup> Information on quota rental and sales values was available for three countries: the Netherlands, Denmark and the United Kingdom. According to this information, the shadow price for dairy farmers participating in the quota market was 50, 80 and 55% of the milk price in these three countries respectively.

**Table 7.11. Shadow price as percentage of milk price at quota level**

EU	BL	DK	D	GR	E	F	IRL
80	79	89	74	94	89	63	74
70	69	78	65	82	78	55	65
60	59	67	55	71	67	47	55
	I	NL	A	P	FIN	S	UK
	84	59	89	94	89	84	69
	74	52	78	82	78	74	60
	63	45	67	71	67	63	50

Concerning the third source of uncertainty about the milk supply function in the post-quota period, namely the likely changes in its position and slope that will result from restructuring stimulated by quota abolition, no hypotheses of this process have been modelled. We assume in all simulations that the shadow milk supply function remains fixed (conditional on the levels of quasi-fixed inputs, which are themselves adjusting). Parameters in all equations are assumed to remain unchanged relative to the pre-quota period.

Unlike the model used in the previous paragraph, dairy cow stocks adjust more freely according to equation (19):

$$z_{4,t} = -\frac{\lambda_4}{\beta_{44}} (\beta_4 + \beta_{14}z_{1,t-1} + \beta_{24}z_{2,t-1} + \beta_{34}z_{3,t-1} + \beta_{45}z_{5,t-1} + \gamma_{14}p_{1,t-1} + \gamma_{24}p_{2,t-1}) + (1 - \lambda_4)z_{4,t-1} \quad (51)$$

Again, to impose exogenous yield growth (rate  $g$ ), equation (51) is reformulated as:

$$z_{4,t} = -\frac{\lambda_4}{\beta_{44}} (\beta_4 + \beta_{14}z_{1,t-1} + \beta_{24}z_{2,t-1} + \beta_{34}z_{3,t-1} + \beta_{45}z_{5,t-1} + \gamma_{14}p_{1,t-1} + \gamma_{24}p_{2,t-1}) \times \frac{1}{1+g} + (1 - \lambda_4)z_{4,t-1} \quad (52)$$

Again, the same set of accounting equations determine gross margins, direct payments (including national envelopes), numbers of animals slaughtered and aggregate quantities at EU level. Results are transposed to specialised dairy farms.

Finally, in order to find the order of magnitude by which milk prices will (have to) adjust when milk output changes in the no-quota scenarios, we add an aggregate demand equation for milk ( $z_5^D$ ). The demand equation is specified (in constant elasticity form) as:

$$z_{5,t}^D = \xi_0 p_{5,t}^{\epsilon_5^D} \quad (53)$$

with  $\xi_0$  a constant and  $\varepsilon_s^D$  a (derived) demand elasticity (at farm gate level). Two elasticities, -0.15 and -0.24, are used in the simulations.

The elasticity of -0.24 is the derived demand elasticity for milk when there are no constraints on subsidised dairy exports. This elasticity is implicit in demand simulations by Bouamra-Mechemache and Réquillart (cf. chapter 8) where it is assumed that export demands for dairy products are elastic. The demand elasticity of -0.15 corresponds to situations where dairy exports are fixed at their WTO limits, so that any increase in milk demand that occurs as price falls has to be due to expansion within the EU market for dairy products. Since all our (no quota) scenarios involve significant increases in milk production, domestic price always falls. We can therefore assume that the WTO export limits are always binding, and thus the appropriate elasticity of demand is around -0.15.

Equation (53) is calibrated based on the indicated elasticity and the assumption that in base year 2000 the aggregated quantity demanded equals aggregated supply (excluding planned quota increase for 2000). With exogenous demand growth (at rate  $d$ ), equation (53) becomes:

$$z_{st}^D = \xi_0 p_{st}^{\varepsilon_s^D} (1+d)^t. \quad (54)$$

#### 7.4.4.2. Quota abolition scenarios

These scenarios begin by assuming the post-Agenda 2000 situation, with quotas maintained up to 2005. The Agenda 2000 price reductions are phased in over three years as stipulated by the regulation. In 2005, quotas are abolished so that milk production is free to expand along the shadow milk supply function. All Agenda 2000 direct payments continue to be paid as defined by the relevant regulations. The scenarios include sensitivity analysis regarding different yield growth rates, differences in assumed quota rents, and differences in demand assumptions. Unless stated otherwise, milk yield growth is assumed to be zero. For the Netherlands, environmental constraints are assumed to be potentially restrictive (see equation (48)) with  $s^{\max} = (1.1) s_{t=2000}$ .

The scenarios explored in this paragraph are summarised in Table 7.12. A standard scenario is chosen in which it is assumed that milk yield is stable and that the average shadow price is 70% of the actual milk price (S20). Alternatively, an exogenous milk yield growth of 1.3% per annum (S20y), or average shadow prices at 80% and 60% of the actual EU milk price level are assumed (S20-80 and S20-60). The scenarios S20, S20y, S20-80 and S20-60 assume a fixed milk price decline of 25%.

The other scenarios reported here assume that the milk price is endogenous. Demand elasticities of -0.15 or -0.24 are assumed. The less elastic demand assumes that exports (estimated at 10% of the milk supplied in 2000) are fixed. This is a limiting case: WTO limits are assumed binding and there is no

possible expansion in unsubsidised exports. The more elastic demand corresponds to the other limiting case where there are no WTO constraints, and demand for EU dairy exports has an average elasticity of  $-2$ . In two scenarios, notably S23 and S23y, a 50% reduction in exports from the 2000 level is assumed.

In the scenarios with an endogenous milk price, equation (53) is included in the simulation model. For scenarios with 1.3% dairy cow yield growth (S21y, S22y and S23y), autonomous demand growth of 1% (starting from base year 2000) is also assumed, as formalised in equation (54).

**Table 7.12. Summary of quota abolition scenarios**

	Average EU shadow price 70% of milk price in 2000 Yield growth is 0% p.a.                      1.3% p.a. Demand growth is 0% p.a.                      1% p.a.		Average EU shadow price 80% of milk price in 2000 Yield growth: 0% p.a.	Average EU shadow price 60% of milk price in 2000 Yield growth: 0% p.a.
Exogenous milk price decline = 25%	S20	S20y	S20-80	S20-60
Endogenous milk price decline $\varepsilon_5^D = -0.15$	S21	S21y	S21-80	S21-60
Endogenous milk price decline $\varepsilon_5^D = -0.24$	S22	S22y		
Endogenous milk price decline $\varepsilon_5^D = -0.15$  Dairy exports = 50% of current WTO allowances	S23	S23y		

#### 7.4.4.3. Simulation results: quota abolition

A summary of the second set of simulation results (quota abolition in 2005) is presented in Table 7.13. Tables with results at Member State level are reported in appendix 3. Assuming that the average shadow price in the EU is 70% of the current milk price, and that in 2005 the exogenous milk price declines by 25% accompanied by quota abolition, scenario S20 shows that milk output will be 17.6% higher in 2010 compared with 2000. The milk increase is due to a 15.3% increase in dairy cows combined with a 2.3% increase in yield. To obtain this yield increase, the feed input per cow increases, with total feed input increasing by 18.9%. The increase in dairy cows (and the beef price decline introduced by Agenda 2000) causes a decline in suckler cow numbers by 27.1% compared

with 2000. Beef output (-1.6%) is nearly the same as in the base year, but with lower output in the years in between 2000 and 2010. Net revenue falls by about 18%.

As is shown in Table 7.27, appendix 3, for scenario S20, quota abolition has different impacts at Member State level. Countries with a relatively low shadow price have an incentive to expand beyond their (now abolished) quota limit, even when the actual milk price falls by 25%. In particular the UK, France, the Netherlands and Germany expand strongly. Spain also shows a significant milk output increase, but much of this is due to the initial quota increase of more than 10% of its milk supply in 1999/2000. For the Netherlands, the environmental stocking density constraint is binding, and overrules equation (48) in the later years.

When a 1.3% autonomous milk yield growth is assumed (scenario S20y), milk output increases by an additional 11.5 percentage points as compared with the zero autonomous yield growth scenario, S20. Dairy cows increase modestly compared with scenario S20 (+2.7 percentage points), while feed input increases more strongly (+3.6 percentage points). Scenarios S20-80 and S20-60 provide sensitivity analysis on the assumed level of shadow prices. If the average shadow price is 80% of the EU milk price in the base year, milk output increases by only 11% compared to the base. If the average shadow price is 60% of the base EU milk price (scenario S20-80), milk output is 38% higher in 2010 compared with 2000.

The S20\* scenarios are unrealistic since they ignore the market constraint, which is relevant in the actual situation. For example, for S20, when domestic demand (calculated by equation (53)) is subtracted from simulated supply, there is evidently an increasing excess supply over time. If the EU wanted to dispose of this surplus by exporting it to the world market, exports (measured in milk equivalents) would have to increase by about 133% in 2010 (i.e. exports more than double their volume compared to 2000). S20\* scenarios only consider the supply side without accounting for the impact output changes will have on market prices. The subsequent scenarios (from S21 to S23y) all take into account the missing market constraint. In scenario S21, the output increase nearly halves as compared with scenario S20. Five Member States, notably Belgium, Italy, Austria, Finland and Sweden, show a milk output fall relative to 2000, albeit a limited one.

It is noteworthy that in all the quota abolition scenarios, the dairy herd expands at the expense of the suckler cow herd.<sup>133</sup> Yet beef production hardly declines, as the dairy herd substitutes for specialist beef animals as a source of beef carcasses.

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<sup>133</sup> Note that in a few countries, notably Germany and the Netherlands, the suckler cow herd (which is relatively small already in the base year) is prevented from going to zero in the simulations.

Table 7.13 also permits a comparison of the different assumptions regarding the size of the quota rent. Comparing S20-80 and S20-60 (scenarios in which milk price is fixed rather than market determined), we see when the quota rent is higher (i.e. lower shadow price of milk relative to the pre-abolition milk price), quota abolition leads to stronger substitution of dairy cows for beef cows and a smaller reduction in gross margins. This is because the price of milk in these scenarios is fixed above its market clearing level, and milk production is more profitable at this fixed price the lower the underlying shadow price is. The strong increase in the quantity of milk produced at this supported price helps to moderate the effect of the 25% price reduction.

**Table 7.13. Simulation results quota abolition (at EU-15 level)**

Variable	year	S20	S20y	S20-80	S20-60	S21	S21y	S21-80	S21-60	S22	S22y	S23	S23y
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	101.1	99.5	101.1	99.5	101.1	99.5	101.1	101.1	101.1	99.5	101.1	99.5
	2008	109.9	108.9	106.8	113.0	106.7	108.8	105.4	108.3	108.5	110.1	103.8	106.2
	2010	115.3	118.0	110.3	125.1	108.8	114.7	107.1	111.4	111.6	117.4	104.8	110.8
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	88.9	90.6	88.9	90.6	88.9	90.6	88.9	88.9	88.9	90.6	88.9	90.6
	2008	77.8	81.9	80.7	78.1	80.4	81.2	81.5	79.0	78.7	80.0	83.0	83.9
	2010	72.9	73.0	77.3	67.2	78.0	74.3	79.4	76.2	75.5	72.2	81.7	78.5
q milk	2000	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6	100.6
	2004	101.2	101.2	101.2	101.2	101.2	101.2	101.2	101.2	101.2	101.2	101.2	101.2
	2008	113.4	118.6	108.9	124.9	107.3	115.5	105.9	109.6	109.9	117.9	103.9	112.2
	2010	117.6	129.1	111.6	138.0	108.2	120.7	106.6	111.2	111.5	124.3	104.4	116.9
q beef & veal	2000	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
	2004	94.9	94.4	94.9	94.4	94.9	94.4	94.9	94.9	94.9	94.4	94.9	94.4
	2008	96.8	97.7	95.4	99.7	95.0	97.2	94.5	95.8	95.9	97.9	93.7	96.1
	2010	98.4	101.1	96.1	104.0	95.1	98.9	94.6	96.4	96.4	99.9	93.8	97.8
q feed	2000	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0	103.0
	2004	105.0	102.6	105.0	102.6	105.0	102.6	105.0	105.0	105.0	102.6	105.0	102.6
	2008	115.7	115.4	111.7	120.6	110.3	112.7	109.0	112.4	112.6	114.7	107.3	110.0
	2010	118.9	122.5	113.8	129.5	110.8	115.4	109.5	113.6	113.5	118.3	107.7	112.6
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	98.9	98.8	98.9	98.8	98.9	98.8	98.9	98.9	98.9	98.8	98.9	98.8
	2008	99.3	98.9	98.9	99.3	99.0	99.0	98.9	99.1	99.2	99.1	98.7	98.7
	2010	100.3	100.3	99.6	101.2	99.5	100.1	99.2	99.9	99.9	100.4	98.9	99.5
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	93.2	93.5	93.2	93.5	93.2	93.5	93.2	93.2	93.2	93.5	93.2	93.5
	2008	79.3	82.8	77.1	86.0	63.5	70.7	67.9	57.1	68.9	76.4	58.3	65.0
	2010	81.7	88.5	78.5	93.2	61.0	63.4	65.7	53.4	66.4	70.3	57.2	60.0

Comparing the scenarios S21-80 and S21-60, where price is endogenous and falls to clear the market, we find an opposite result. The higher the quota rent (i.e. the lower the shadow price), the smaller the increase in milk production and the smaller the knock-on effect on suckler cows, but the greater the fall in gross margins. This occurs because the lower shadow price exerts a stronger incentive to increase production, but to clear the market price has to fall very steeply. Of course, this price fall both moderates the milk production increase and also has a heavy impact on the gross margin, despite the contribution of direct payments.

As Table 7.14 shows, the output increase that occurs in the scenarios with a fixed price is strongly held back by a strong milk price decline when milk price becomes endogenous and the market is forced to balance. The price fall is 75% greater in S21 (-44%) compared with S20 (-25%). If autonomous milk yield growth of 1.3% is allowed for (scenario S21y), the milk price declines by nearly 50%.

Not surprisingly, compared with the S20\* scenarios, which assume a fixed 25% price decline, the endogenous price scenarios predict a much lower "gross margin", about 40% lower than in the base year. Comparing scenarios S22 and S22y with scenarios S21 and S21y provides some sensitivity analyses with respect to the demand elasticity.

**Table 7.14. Milk price changes, endogenous price scenarios (percentage change from 2000)**

year	S20	S20y	S20-80	S20-60	S21	S21y	S21-80	S21-60	S22	S22y	S23	S23y
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2005	-25.0	-25.0	-25.0	-25.0	-30.9	-17.8	-25.8	-36.5	-25.2	-14.5	-40.7	-28.3
2008	-25.0	-25.0	-25.0	-25.0	-40.6	-37.0	-34.4	-49.1	-35.3	-31.7	-45.2	-41.9
2010	-25.0	-25.0	-25.0	-25.0	-44.0	-47.7	-37.7	-54.3	-39.3	-41.8	-46.9	-50.0

When demand is more elastic (elasticity equal to  $-0.24$  instead of  $-0.15$ ), milk output increases by a further 3.3 percentage points (S22). When there is also yield growth, the increase in dairy cow numbers (S22y) nearly fully offsets the suckler cow decline, and beef & veal output in 2010 is nearly the same as in 2000. With both these scenarios, milk price declines less and output increases more than in the "inelastic" demand scenarios. Gross margin is also higher. However, the milk price still has to decline by about 40% in order to clear the market.

Comparing scenarios S21, S22 and S23 with their counterparts S21y, S22y and S23y (which assume both yield growth and demand growth), we see that in 2005 the price fall is less in the with-growth scenario than in the corresponding without-growth scenario. This is because output expansion, on the supply side, has been held back by quotas, whereas demand has grown by 1% each year from the beginning of the simulation period. However, once quotas are removed the faster yield growth soon outstrips the growth in demand, so that by 2010 and the price fall in the with-growth scenarios exceeds that in the without-growth scenarios.

As already mentioned, a total demand elasticity of  $-0.24$  corresponds to a situation where there are no constraints on subsidised exports. In reality, subsidised exports are constrained by the Uruguay Round commitments. When it is assumed that dairy exports are reduced by half (5.5 million tons milk

equivalents less), milk output increases by only 4% compared with the base year. The output increase halves when comparing it to the same scenario (see S21) without the 50% reduction in export allowances. Assuming a 50% reduction in exports and 1.3% autonomous milk yield growth (scenario S23y) leads to an output increase of nearly 4 percentage points less but with a further 2 percentage point price decrease, as compared with scenario S21y.

#### ***7.4.5. Impact of scenarios on specialist dairy farms***

The decline in gross margin shown in the tables above and in the appendix summarises the results to dairying and beef and veal *production*, taken together. It is interesting, however, to compare scenarios S10, S20 and S21 with respect to their impact on specialist dairy *farms* in the Member States. The gross margins shown in most of the tables, including Table 7.13, correspond to revenue earned only from milk and beef/veal. It is more properly a "margin over feed cost" for these enterprises, since feed is the only variable input whose cost has been deducted. The interest of this gross margin calculation is that the definition is clear, and it is a useful indicator for comparing changes across different scenarios. The fact that it does not compound too many effects makes it useful as a comparative measure.

Paragraph 7.3.6 explained the simple methodology underlying the translation of sectoral production-based gross margins to farm-based gross margins, which recognise other sources of revenue and other variable costs apart from feed. The gross margin changes for the representative specialist dairy farm in each Member State that are presented in Table 7.15 have been calculated using this methodology.

The information in these tables can be compared with the country-specific changes in production-defined "gross margins" (margin over feed costs) shown in the corresponding appendix tables. For all scenarios and all Member States, the farm-level gross margin reduction is smaller than the measured reduction in margin over feed costs. In scenario S21 (quota abolition, endogenous prices), the reduction in specialist dairy farm gross margins is about 8-15 percentage points smaller than the reduction in the milk and beef margin over feed costs. Although these figures are indicative only, they act as a reminder that the "gross margin" calculation shown in most of the tables ignores other farm enterprises and their changes probably over-estimate the changes in whole-farm gross margins. Having said this, it should also be borne in mind that additional items on the cost side, which must be deducted before arriving at a net income figure, tend to be relatively fixed in the short to medium term. Therefore, the whole-farm gross margin estimates shown in Table 7.15 may well under-estimate the full impact of these different scenarios on specialist dairy farmers' incomes.

**Table 7.15. Gross margins on specialist dairy farms** (percentage changes comparing 2010 with 2000)

<b>Country</b>	<b>B</b>	<b>DK</b>	<b>D</b>	<b>GR</b>	<b>E</b>	<b>FR</b>	<b>IRL</b>
Scenario S10	-3.4	-5.2	-3.4	-3.6	-2.2	-4.4	-8.0
Scenario S20	-10.3	-6.1	-3.2	-12.5	-12.4	-0.2	-11.5
Scenario S21	-35.9	-31.1	-28.0	-32.2	-33.6	-25.5	-33.4
<b>Country</b>	<b>IT</b>	<b>NL</b>	<b>A</b>	<b>P</b>	<b>FIN</b>	<b>S</b>	<b>UK</b>
Scenario S10	-1.7	-3.0	-3.7	-1.4	-4.0	-4.3	-1.9
Scenario S20	-10.5	2.5	-12.4	-3.7	-13.1	-12.4	2.1
Scenario S21	-31.9	-23.7	-31.4	-22.8	-35.2	-35.7	-30.6

## 7.5. Discussion and conclusions

### 7.5.1. Technical discussion of model simulations

Before simulating the scenarios of interest, the model was tested in various ways in order to evaluate its performance as a tool for simulation. In particular, we wanted to check that simulation results under a wide range of assumed scenarios would satisfy certain plausibility checks: technologically and biologically feasible relationships between animal numbers and animal outputs, feasible stocking rates and economically plausible implicit long-run elasticities. It was especially important to check that simulation results for individual Member States did not imply reactions that were beyond their production capacity in the medium term.

All our checks were satisfied, at the level of individual Member States and for the EU as a whole, confirming that the system does indeed represent the capacities and trade-offs of the dairy-beef sector in a realistic way.

All the simulated scenarios began with Agenda 2000, starting with its implementation for beef and cereals in 2000/2001, and supplemented by dairy in 2005/6. In this report, we show simulation results only up to 2010. However, given the highly dynamic nature of the model, adjustment was not fully complete by 2010. For some scenarios, a small but significant part of the adjustment continued up to about 2014. The adjustment lags explicitly concern the adjustments to quasi-fixed factors. However, since it is these factors - particularly dairy and beef cow stocks - that drive the system, their gradual adjustment means that variable inputs and outputs (milk, beef, feed use) are also adjusting with a long lag.

In particular, the tabulated simulation results show relatively little movement in land allocation. Since land is the quasi-fixed factor that reacts most slowly in the model, one might wrongly conclude that the small movement registered up to 2010 is the result of very slow adjustment, and that further significant adjustment can be expected beyond 2010. In fact, this small response is largely due to the low (although statistically significant) responsiveness of the land adjustment equation to price signals, and to the fact that movements in dairy and beef cow numbers tend to offset each other to some extent. Thus, there is no delayed land "explosion" in years beyond 2010. Given the stability of land allocated to dairy and beef in past years, this should not be surprising.

In the endogenous price scenarios, the fact that the market for raw milk is modelled at EU level rather than at the level of individual Member States calls for some comment. The role of the aggregate demand function is to "close" the model, and to allow realistic solutions in which quantity produced and market price interact to reach a mutually consistent solution compatible with market balance, taking domestic and export demand into account. It is true that there are currently and historically considerable differences between member countries in the producer price of milk, with highest prices observed in Italy and lowest prices in the highly competitive milk producing countries of the North (the Netherlands, Belgium, France). It is, however, debatable whether national milk markets would remain so segmented after quota abolition. As long as national quotas and strong quota-induced links with particular dairy companies exist, the possibilities for cross-border trade in raw milk have been rather limited, although intra-Union trade in dairy products has increased very strongly. The extent to which increased cross-border trade in raw milk would tend to equalise producer prices (after taking account of transport costs) if quotas are removed is unknown. Studies of price transmission for freely traded agricultural products in the European Union have given mixed results (Palaskas and Crowe, 1996; Zanas, 1992). In summary, then, it has been impossible to test this feature of the model empirically, although we believe it to be a reasonable approximation of the way the market is likely to work in a future post-quota period.

### *7.5.2. Discussion of sensitivity analyses*

In this section, we discuss the results of sensitivity analyses concerning decoupling, autonomous yield growth and the magnitude of the quota rents.

#### *7.5.2.1. Decoupling*

The main result here is that the extent to which direct payments are perceived as decoupled does not have a major impact on aggregate market outcomes. Comparing the scenarios in which a minimum (S10) and maximum (S11.4) degree of perceived coupledness are assumed, we find that the more coupled the package of payments is perceived to be, the more beef animals are held (dairy cows are

implicitly constrained by the milk quota constraint in these scenarios). By 2010, the fall in suckler cows relative to 2000 is about 6% when payments are viewed as coupled, rather than over 17% when they are not. Feed input and land allocation increase more or less proportionately to non-dairy beef production, but the fall in gross margin for the beef/dairy sector as a whole is less by only about 2 percentage points (relative to the base year). Similarly, the impact on total beef production is of a smaller order of magnitude (fall of 3% rather than about 7%).

Scenario S11.1, which assumes that only slaughter premiums are perceived as coupled to output, is perhaps the most realistic. In this scenario, we find that the impact on suckler cow numbers, after 10 years, is still relatively small (a decline from the base year of a little more than 14% rather than over 17%). Of course, the impact of this difference on beef production is much smaller, due to the fact that such a significant proportion of beef comes from the dairy herd which, in these simulations, is implicitly constrained by quota.

#### *7.5.2.2. Yield growth*

The simulations in section 7.4 analyse Agenda 2000 with and without the maintenance of quotas under two different assumptions about yield growth: zero yield growth and autonomous yield growth at the rate of 1.3% per year beginning in the base year. In the quota-abolition simulations where yield is increasing, we also assume 1% annual growth in demand for raw milk. Comparing the different yield assumptions with quotas maintained (S10 and S10y), we find that when yield is trending, there is significant substitution of suckler cows for dairy cows as quota commitments can be met by progressively fewer dairy cows. The net effect of these two movements on beef production is relatively small.

When quota is abolished, and price is endogenous, the relevant scenarios to compare are S21 and S21y. With yield growth, the expansion in the dairy herd is substantially greater than with no yield growth, and the increase in milk production, relative to 2000, is more than doubled. Beef output is a little higher, as is feed use. Surprisingly, the impact on gross margin is small. Although a larger quantity of milk is being produced, milk price is lower. The stabilising effect on gross margin changes of beef revenue is apparent in the comparison between these two scenarios.

This analysis indicates that, whether one is interested in marketed outputs or agricultural incomes, it is important to analyse the effect of milk yield changes in a model that also represents the interaction between dairy and beef animal populations, and the contribution of beef to the incomes of dairy producers.

### *7.5.2.3. Quota rents*

We have analysed the sensitivity of the model to different assumptions about quota rents under two different policy settings: quota abolition with milk price exogenously supported (compare S20-60 and S20-80), and quota abolition with milk price endogenously determined (compare S21-60 and S21-80). In the first situation, when rents are higher (i.e., the shadow price for milk is lower, indicating lower-cost production at the margin), the expansion in dairy cow numbers and milk production following quota abolition is much greater than when rents are lower. Feed use is also much greater, and the fall in gross margins significantly smaller (a fall of just under 7%, compared with 2000, rather than over 21%). These results appear to confirm the idea that the more efficient milk production is at the margin, the better able milk producers will be able to cope with quota abolition.

However, such a conclusion is misleading. These two scenarios assume that milk price is still supported. The level of support (25% less than in the base year) represents a price decline that might be considered politically acceptable but it is not sufficient to ensure market balance, even with the EU's current exporting opportunities. Underlying the simulation results for S20-60 and S20-80, is a growing market imbalance that is not sustainable in the medium term.

When price becomes endogenous so as to clear the market, comparison between scenarios S21-60 and S21-80 shows that stronger price falls occur in the high rent simulation: lower-cost producers have a greater incentive to expand but this works against them by driving price down lower. The implication is that, the higher the quota rents observed now, the greater has been the effect of the quota scheme over the past 15 years in holding back restructuring in the sector. The fall in gross margin of over 46% by 2010 that is shown for the S21-60 scenario suggests that, the closer EU producers are now to world market production costs, the more urgent and substantial would be the restructuring of production capacity (into a smaller number of much larger production units) if the milk-producing sector were completely deregulated.

### *7.5.3. Policy conclusions*

From the 19 scenarios analysed, the following general conclusions can be drawn:

- ✓ The proposed dairy policy reform in Agenda 2000 (milk price decline of 15% with limited quota enlargement: milk output +2.4% and compensatory payments) is successful in curbing output growth and maintaining farm incomes at levels comparable to those of the base year.
- ✓ Abolishing quota, but at the same time maintaining the existing CMO by guaranteeing a fixed price, albeit 25% lower than at present, will lead to a significant output increase, in particular

when yield growth continues to follow its past trend. This does not look like a sustainable policy option, and will result in growing market imbalance.

- ✓ Quota abolition with market-determined prices is likely to lead to a milk output increase of more than 25% (allowing for exogenous yield growth and demand growth of 1.3% and 1% per year respectively) with an accompanying milk price fall of 40% or more. We stress that the simulated price decline balances the internal market, given that border protection for dairy products and subsidised export arrangements are maintained unchanged. The price decline has disastrous impacts on the gross margin (revenue plus direct payments minus feed costs) of the dairy-beef sector. Even when the compensatory direct payments of Agenda 2000 are assumed to continue when quotas are removed, gross margin falls by roughly 40%.
- ✓ The calculated impacts on the whole-farm gross margins of specialist dairy farms are somewhat smaller than those predicted for the dairy-beef sectors as a whole (these calculations take into account other sources of revenue from farming).
- ✓ The output increase following quota abolition would lead, in the absence of any export limits, to a significant increase in the EU's exportable surplus.
- ✓ If the ex-farmgate milk price declines by an order of magnitude of 40%, the EU price level is coming closer to world market price levels and there may be some scope for increasing unsubsidised exports of dairy products (Agra Europe, 2001, A/1).
- ✓ When a 50% decrease in export volumes is assumed, relative to the level of exports in 2000, there is additional pressure on internal price and a further reduction in milk output. This scenario would correspond to a reduction of 50% or more in the EU's bindings on subsidised dairy products.
- ✓ Agenda 2000, with or without quota abolition, leads to stabilisation, or even a slight reduction, in the EU's beef and veal output.

## APPENDIX 1

### Background tables

Table 7.16. Stocking densities, Member States, 1973-1995, dairy cow equivalent per hectare of grazing and forage land

Year	BL	DK	D	GR	E	F	IRL	I	NL	A	P	FIN	S	UK
73	1.24	1.51	0.90	0.59	0.30	0.54	0.37	0.54	1.53	0.72	2.00	0.96	2.04	0.41
74	1.28	1.61	0.93	0.62	0.29	0.56	0.38	0.54	1.62	0.56	1.71	0.82	1.58	0.43
75	1.28	1.62	0.92	0.62	0.29	0.57	0.40	0.53	1.68	0.57	1.53	0.82	1.55	0.43
76	1.26	1.64	0.92	0.61	0.29	0.56	0.37	0.52	1.67	0.56	1.34	0.81	1.51	0.41
77	1.27	1.70	0.91	0.62	0.30	0.57	0.38	0.52	1.69	0.55	1.19	0.81	1.47	0.41
78	1.29	1.71	0.92	0.62	0.31	0.57	0.39	0.53	1.71	0.55	1.09	0.81	1.44	0.41
79	1.34	1.70	0.99	0.63	0.31	0.57	0.39	0.54	1.78	0.55	0.94	0.82	1.43	0.41
80	1.36	1.69	0.99	0.63	0.31	0.59	0.39	0.55	1.82	0.54	0.88	0.83	1.42	0.42
81	1.35	1.72	1.00	0.62	0.32	0.58	0.38	0.54	1.83	0.54	0.78	0.84	1.42	0.41
82	1.34	1.71	0.99	0.63	0.33	0.59	0.37	0.54	1.88	0.54	0.70	0.81	1.42	0.42
83	1.37	1.69	1.01	0.63	0.35	0.59	0.38	0.56	1.93	0.54	0.65	0.81	1.36	0.43
84	1.39	1.70	1.04	0.63	0.36	0.60	0.39	0.58	1.94	0.54	0.60	0.85	1.36	0.43
85	1.41	1.73	1.01	0.66	0.37	0.59	0.39	0.55	1.88	0.55	0.55	0.83	1.36	0.43
86	1.40	1.70	0.99	0.59	0.37	0.58	0.39	0.54	1.80	0.55	0.55	0.76	1.35	0.43
87	1.42	1.71	1.00	0.64	0.38	0.58	0.38	0.55	1.78	0.56	0.55	0.80	1.26	0.44
88	1.43	1.58	0.95	0.67	0.40	0.57	0.37	0.56	1.63	0.55	0.54	0.83	1.23	0.44
89	1.44	1.51	0.95	0.68	0.40	0.58	0.39	0.58	1.63	0.50	0.50	0.81	1.19	0.45
90	1.47	1.54	0.67	0.69	0.41	0.59	0.42	0.56	1.63	0.49	0.54	0.78	1.20	0.45
91	1.46	1.54	0.94	0.71	0.43	0.59	0.43	0.57	1.64	0.48	0.53	0.82	1.23	0.49
92	1.44	1.49	0.84	0.71	0.43	0.59	0.44	0.52	1.63	0.47	0.54	0.75	1.13	0.47
93	1.39	1.36	0.82	0.72	0.42	0.58	0.46	0.51	1.57	0.46	0.53	0.66	1.11	0.48
94	1.38	1.56	0.83	0.72	0.38	0.56	0.46	0.50	1.56	0.46	0.54	0.65	1.08	0.53
95	1.40	1.62	0.82	0.71	0.38	0.59	0.46	0.50	1.51	0.46	0.50	0.57	0.91	0.54
average	1.37	1.62	0.93	0.65	0.35	0.58	0.40	0.54	1.71	0.53	0.84	0.79	1.35	0.44

Table 7.17. Gross margin calculations for specialist dairy farms in the base year, 2000

	Country															EU-15
	BL	DK	D	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK		
<b>Characteristics</b>																
number of dairy cows	33.4	44.8	23.8	25.5	12.0	29.2	29.8	21.0	49.4	8.8	16.2	15.0	29.6	66.8	26.2	
yield per cow	4980.7	6544.8	5308.0	4316.2	5015.3	5379.2	4283.3	5191.0	6356.2	4455.8	4326.9	6134.0	6859.0	5582.7	5338.1	
number of suckl.cows	8.0	5.3	2.2	3.7	2.6	8.9	8.7	2.3	1.2	0.4	3.4	0.2	2.1	14.7	4.4	
total feed use (x1000kg)	86.6	58.1	68.0	18.6	52.7	46.8	17.0	61.9	123.8	12.6	48.7	8.4	10.1	176.1	59.9	
other revenue Euro/cow	184.4	274.9	399.8	528.0	335.4	191.0	77.3	479.6	366.6	398.1	216.2	266.9	291.9	226.1	301.2	
non-feed input cost Euro/cow	227.0	349.4	326.7	366.9	124.9	274.1	263.8	137.9	389.0	276.6	150.2	339.3	371.0	325.2	294.7	
<b>BASE YEAR 2000</b>																
<i>All values in Euro</i>																
<b>Revenues</b>																
qm*pm(shadow)	35037.9	77276.2	25989.7	49010.4	13813.7	23225.8	26476.1	26828.0	50145.3	10473.6	10756.7	23764.6	52039.4	74133.2	32432.2	
qm*qm (quota rent)	15016.3	19319.1	13994.4	8648.9	3453.4	23225.8	14256.4	8942.7	50145.3	2618.4	1898.2	5941.2	17346.5	49422.1	12782.7	
milk	50054.2	96595.3	39984.1	57659.3	17267.1	46451.6	40732.5	35770.7	100290.7	13092.0	12655.0	29705.8	69385.9	123555.3	45214.9	
beef & veal	18054.1	22118.8	9798.4	12235.5	7064.1	20538.2	16735.5	11252.5	23149.8	3553.0	6526.5	5258.5	10474.7	37459.5	15034.0	
other revenues	7634.9	13779.3	10363.1	15405.2	4916.5	7278.3	2973.7	11173.8	18543.0	3668.6	4227.7	4058.4	9269.5	18428.9	9210.3	
total	75743.3	132493.5	60145.6	85300.0	29247.7	74268.1	60441.8	58197.1	141983.5	20313.6	23409.1	39022.7	89130.1	179443.6	69459.1	
<b>Direct payments</b>																
dairy	270.4	362.9	192.4	206.5	97.5	236.6	241.2	170.5	400.0	71.5	131.2	121.2	240.1	541.4	212.1	
beef & veal	2169.2	1656.3	727.6	1091.1	719.8	2326.3	2289.2	720.7	752.0	173.4	926.8	198.7	771.9	4015.1	1261.6	
total	2439.6	2019.3	920.0	1297.7	817.3	2562.9	2530.5	891.2	1152.0	244.9	1058.1	319.9	1012.0	4556.5	1473.7	
<b>Variable costs</b>																
feed	19218.7	10624.3	9008.7	7333.4	9981.8	11051.5	4932.2	19383.2	20841.9	3104.6	5383.0	1327.4	3208.9	48976.3	14235.7	
other costs	9399.7	17515.6	8468.5	10705.2	1830.9	10442.1	10154.2	3212.5	19678.9	2549.4	2937.8	5158.8	11783.0	26503.8	9008.8	
total	28618.5	28140.0	17477.2	18038.5	11812.7	21493.6	15086.4	22595.7	40520.8	5653.9	8320.8	6486.2	14991.9	75480.2	23244.6	
<b>Gross margin</b>	49564.4	106372.7	43588.4	68559.2	18252.3	55337.5	47885.9	36492.5	102614.7	14904.6	16146.4	32856.5	75150.3	108520.0	47688.3	

**Table 7.18. Meat composition at Member State level**

		Country															EU-15
		B	DK	GER	GR	SP	FR	IRL	IT	LUX	NL	A	P	FIN	S	UK	EU-15
Total cows	x1000	1171	789	5535	301	3006	8310	2456	2677	72	1723	879	632	408	596	4393	32947
Dairy cows	x1000	606	661	4758	171	1292	4125	1279	2106	45	1630	699	347	381	435	2461	20994
Other cows	x1000	565	128	777	130	1714	4185	1178	571	27	93	180	285	28	161	1932	11953
%suckler cows	fraction	48	16	14	43	57	50	48	21	37	5	20	45	7	27	44	36
Slaughterings	x1000	1090	710	5083	279	2462	7100	2336	2960	50	1786	771	383	373	496	2232	28111
calves	x1000	401	106	750	46	120	2547	138	377	17	916	181	129	15	34	82	5859
young bulls/steers	x1000	261	270	1938	165	1205	1935	1156	1440	10	189	303	147	187	234	1318	10758
cows	x1000	363	269	1620	34	352	1808	393	661	13	577	183	64	127	179	0	6643
heifers	x1000	65	65	775	34	785	810	649	482	10	104	104	43	44	49	832	4851
Av. slaughter wght	kg/animal																
calves	kg/animal	158.7	97.6	119.9	149.5	159.8	126.1	90.9	140.8	125.0	157.4	90.4	120.9	92.9	96.4	41.3	130.2
young bulls/steers	kg/animal	449.4	277.4	343.9	262.3	279.6	389.9	344.2	312.8	385.7	364.4	379.4	300.9	267.9	300.2	323.5	336.5
cows	kg/animal	387.5	239.2	296.5	226.2	241.1	336.2	296.8	269.7	332.6	314.2	327.1	259.4	231.0	258.8	279.0	303.8
heifers	kg/animal	370.0	228.4	283.1	216.0	230.2	321.1	283.4	257.5	317.6	300.0	312.3	247.7	220.6	247.1	266.4	275.3
Meat production	1000t	345636	164426	1456010	65196	621576	1943703	711047	805824	13481	425549	223657	87076	90545	131957	651376	7737059
calves	1000t	63629	10346	89888	6878	19170	321177	12544	53072	2125	144178	16367	15593	1393	3278	3385	763022
young bulls/steers	1000t	117293	74894	666387	43283	336867	754544	397919	450371	3857	68870	114945	44227	50104	70239	426381	3620182
cows	1000t	140664	64340	480324	7691	84852	607922	116647	178261	4324	181298	59861	16604	29341	46330	0	2018458
heifers	1000t	24051	14845	219412	7343	180687	260061	183936	124120	3176	31203	32484	10652	9707	12110	221611	1335398
member state share		0.04	0.02	0.19	0.01	0.08	0.25	0.09	0.10	0.00	0.06	0.03	0.01	0.01	0.02	0.08	1.00

Comment: Although here separately mentioned, in the model simulations Luxembourg is jointly with Belgium treated as one country. For the UK the value of zero is because beef from animals older than 30 months cannot enter the human food chain in the UK due to BSE problems.

**Table 7.19. Effective prices when direct payments are perceived as coupled (calculated at Member State level)**

Direct payments perceived as coupled cumulative	Country													
	B	DK	D	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK
<b>Beef and veal</b>														
slaughter premiums on all animals	-14.64	-14.85	-14.85	-15.19	-15.00	-14.72	-15.03	-15.02	-14.32	-14.94	-14.92	-15.02	-14.98	-15.19
suckler cow premiums and special premiums	-7.33	-6.78	-6.78	-8.61	-7.00	-7.44	-6.97	-7.49	-7.84	-7.27	-8.38	-6.90	-6.87	-7.46
national envelope beef	-5.17	-4.70	-4.71	-6.64	-4.98	-5.32	-4.96	-5.47	-5.56	-5.23	-6.31	-4.89	-4.84	-5.50
corrected non-feed costs	-2.07	-1.87	-1.87	-3.71	-2.21	-2.25	-2.22	-2.63	-2.12	-2.37	-3.22	-2.16	-2.09	-2.79
<b>Dairy</b>														
Agenda 2000 milk price at farm gate level	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75	-16.75
milk premium	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68	-10.68
national envelope dairy	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11	-8.11

APPENDIX 2

Simulation results: Agenda 2000

Table 7.20. Simulation results scenario S10

Variable	year	Country															
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15	
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	101.5	102.3
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.5	101.6	102.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.3	74.3	73.3	92.6	88.8	92.0	82.3	94.1	39.7	61.0	86.3	70.6	91.0	89.3	88.1	
	2008	80.8	67.2	50.4	92.4	88.2	91.2	72.0	94.1	11.7	30.8	70.3	55.4	84.7	85.4	83.4	
	2010	80.5	66.5	39.8	92.6	89.3	92.1	68.6	95.3	11.7	13.8	62.1	48.5	82.3	85.1	82.5	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2	
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5	
	2004	93.0	93.4	94.5	104.1	93.8	94.3	94.5	100.1	95.2	91.0	91.9	96.7	96.7	95.4	95.2	
	2008	88.1	92.4	92.5	103.4	91.4	94.0	89.1	100.0	93.3	84.9	84.0	97.0	94.1	93.7	93.3	
	2010	87.3	92.4	90.8	103.6	92.4	94.5	87.3	100.3	93.3	81.3	79.5	96.7	92.7	93.4	92.8	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0	
	2004	100.7	102.9	102.1	109.1	110.0	110.8	102.4	110.9	101.6	101.9	102.0	99.7	106.5	100.4	105.3	
	2008	101.2	104.3	103.1	108.8	109.8	111.4	104.5	111.3	103.4	102.4	103.5	99.9	108.8	101.3	106.1	
	2010	101.4	104.4	102.9	108.9	110.0	111.6	105.2	111.4	103.6	102.1	103.3	99.6	109.1	101.4	106.1	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	95.9	97.2	99.4	100.2	99.8	98.5	99.0	100.3	97.7	99.0	97.5	98.6	95.9	98.3	99.0	
	2008	92.8	96.9	99.5	100.3	99.6	98.5	97.1	100.4	95.9	97.4	93.6	98.6	92.2	96.7	98.3	
	2010	92.2	97.0	99.5	100.3	99.6	98.7	96.4	100.4	95.7	96.7	91.4	98.7	90.9	96.3	98.2	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	103.1	97.8	98.0	105.1	98.6	96.1	96.8	100.1	96.6	95.1	100.6	99.1	99.1	98.9	97.9	
	2008	94.8	92.5	92.1	96.5	91.1	92.2	88.9	94.5	91.1	87.2	91.6	94.3	93.2	92.5	92.2	
	2010	95.5	92.6	91.2	92.7	93.0	93.3	87.0	93.0	92.5	84.6	89.2	92.4	92.2	91.3	91.9	

Table 7.21. Simulation results scenario S10y

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.2	95.7	95.2	104.1	103.9	95.3	97.8	101.0	95.3	95.9	95.3	95.4	95.1	95.5	
	2008	91.7	92.0	91.7	99.0	99.1	91.7	92.9	96.1	91.7	92.0	92.0	91.8	91.6	91.9	
	2010	89.4	89.8	89.4	96.4	96.6	89.5	90.5	93.7	89.5	89.9	89.8	89.6	89.4	89.7	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	98.5	79.5	106.0	95.3	89.4	95.5	86.3	95.2	73.9	87.7	88.2	105.7	94.5	90.3	
	2008	104.1	79.1	150.4	99.1	89.3	99.5	82.4	97.4	62.4	121.0	74.9	156.3	92.3	86.8	
	2010	111.1	81.3	177.6	101.2	90.7	102.7	82.4	99.6	59.4	138.1	67.0	182.9	91.4	86.0	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	
	2004	93.0	90.2	92.8	100.4	92.9	93.0	92.8	96.6	91.7	90.5	89.7	93.1	93.3	92.8	
	2008	91.8	85.7	94.7	97.2	89.7	92.4	87.2	92.9	86.5	92.2	79.7	91.6	87.2	87.9	
	2010	93.1	84.0	96.0	96.2	90.3	92.8	85.4	91.4	83.7	93.4	73.7	90.6	83.8	85.6	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	
	2004	99.5	99.9	99.7	106.8	106.9	109.7	99.9	106.0	98.3	98.7	98.8	98.7	104.3	97.6	
	2008	100.4	98.1	99.2	104.6	103.4	110.2	99.1	100.1	96.8	96.9	97.2	100.0	105.0	96.0	
	2010	100.8	96.6	98.3	103.7	102.0	110.4	98.4	97.2	95.2	95.7	95.6	100.3	104.8	94.8	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	95.3	96.6	98.5	100.1	99.6	97.9	98.6	100.0	97.1	98.6	96.9	97.9	95.0	97.7	
	2008	92.0	95.0	97.5	100.0	98.8	97.0	96.4	99.6	93.8	96.1	90.5	96.6	88.8	94.5	
	2010	91.4	94.4	97.1	99.9	98.6	96.7	95.5	99.4	92.5	94.8	86.6	96.1	85.8	93.0	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	104.4	96.9	98.0	103.9	99.3	95.7	96.0	99.5	95.7	95.4	100.8	98.0	98.1	98.4	
	2008	98.9	90.7	94.7	94.5	92.7	92.1	88.5	93.5	89.4	91.9	92.3	92.8	91.1	91.0	
	2010	100.6	91.3	95.1	91.4	95.5	93.5	87.6	93.2	90.5	90.8	92.1	91.5	90.7	90.3	

**Table 7.22. Simulation results scenario S10f**

Variable	year	Country					Country										EU-15
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK		
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.1	101.2	
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	102.3	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.6	102.4	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	91.6	79.6	76.3	92.6	88.8	92.6	82.7	93.9	50.8	62.7	87.2	73.9	92.3	89.9	89.0	
	2008	85.1	74.4	55.4	92.3	88.0	91.5	72.7	93.6	11.7	36.4	73.9	60.1	87.9	86.9	84.5	
	2010	83.7	73.5	44.5	92.4	88.5	91.7	69.2	94.2	11.7	20.6	67.2	51.9	86.2	86.4	83.2	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2	
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4	
q beef & veal	2000	99.2	99.1	99.1	99.7	100.3	99.5	99.5	98.9	99.2	99.1	98.9	99.4	100.0	99.5	99.4	
	2004	93.7	94.3	94.7	103.3	93.2	94.2	94.3	100.0	95.7	91.3	92.2	96.5	97.1	95.3	95.2	
	2008	90.6	93.9	93.1	102.6	90.7	93.9	89.2	99.9	93.7	86.0	85.8	96.9	95.8	94.2	93.7	
	2010	89.3	93.9	91.4	102.7	91.2	94.0	87.3	100.1	93.7	82.8	82.2	96.6	94.9	93.9	93.1	
q feed	2000	100.2	100.7	100.6	104.2	104.7	102.9	100.3	102.9	100.4	100.7	100.6	99.8	101.3	100.4	101.7	
	2004	98.8	101.3	100.6	107.3	108.2	102.7	101.3	109.3	100.5	100.2	100.3	98.0	101.8	98.5	102.4	
	2008	99.5	102.7	101.7	107.0	107.9	103.4	103.2	109.7	102.1	100.9	101.8	98.4	103.6	99.5	103.2	
	2010	99.2	102.8	101.4	107.0	108.0	103.3	104.0	109.7	102.2	100.6	101.6	97.9	103.8	99.6	103.2	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	97.6	98.5	99.6	100.3	100.0	99.1	99.1	100.3	98.7	99.3	98.6	99.3	97.8	99.0	99.4	
	2008	95.7	98.3	99.7	100.3	99.8	99.1	97.3	100.3	97.3	98.1	95.7	99.3	95.6	98.0	98.9	
	2010	95.2	98.4	99.8	100.3	99.8	99.2	96.7	100.4	97.1	97.6	94.2	99.4	94.9	97.8	98.8	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	103.1	97.9	97.5	104.6	96.5	96.0	96.4	98.5	96.3	94.6	98.4	98.8	99.2	97.8	97.4	
	2008	95.8	92.8	91.8	95.9	88.9	92.2	88.7	92.7	90.7	87.2	90.8	94.1	93.8	91.6	91.7	
	2010	96.0	92.8	90.8	92.0	90.5	93.0	86.7	91.1	92.1	84.5	88.7	92.1	92.6	90.4	91.3	

**Table 7.23. Simulation results scenario S11.1**

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	102.3
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.6	102.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.9	78.2	78.7	92.7	91.3	93.8	85.7	95.1	50.5	70.0	89.4	76.3	92.7	91.6	90.6
	2008	83.1	71.7	58.7	92.6	91.0	93.1	77.6	95.3	11.7	44.2	75.9	62.2	86.7	88.2	86.4
	2010	83.0	70.9	48.7	92.8	92.2	94.0	75.2	96.5	11.7	28.9	68.9	55.4	84.4	88.0	85.8
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	93.7	93.9	95.1	104.2	96.0	95.2	95.6	100.3	95.6	92.5	92.9	97.0	97.2	96.1	95.9
	2008	89.2	93.1	93.6	103.5	94.2	95.1	91.3	100.3	93.3	87.5	86.4	97.4	94.8	94.7	94.4
	2010	88.6	93.1	92.0	103.7	95.4	95.5	90.0	100.6	93.3	84.3	82.6	97.1	93.5	94.4	94.1
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	101.0	102.9	102.2	109.2	110.4	111.3	102.1	111.0	101.7	102.1	102.2	99.9	106.6	100.8	105.5
	2008	101.6	104.4	103.3	108.9	110.3	112.0	103.7	111.4	103.4	102.9	103.8	100.3	108.8	101.9	106.4
	2010	101.8	104.5	103.1	109.0	110.5	112.2	104.3	111.5	103.5	102.6	103.7	99.9	109.2	102.0	106.4
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	96.0	97.3	99.4	100.2	99.9	98.6	99.2	100.4	97.8	99.1	97.7	98.7	96.0	98.3	99.1
	2008	93.2	97.0	99.5	100.3	99.8	98.6	97.7	100.4	96.0	97.7	94.1	98.6	92.5	96.9	98.5
	2010	92.7	97.1	99.6	100.3	99.9	98.8	97.2	100.5	95.8	97.1	92.3	98.8	91.3	96.6	98.4
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	103.6	98.0	98.3	105.2	100.2	96.6	97.5	100.3	96.8	95.8	101.7	99.2	99.3	99.1	98.3
	2008	95.6	92.8	92.6	96.6	93.3	92.9	90.4	94.7	91.1	88.5	94.1	94.5	93.4	92.9	92.8
	2010	96.2	92.9	91.7	92.7	94.7	93.8	88.6	93.1	92.5	85.8	91.9	92.5	92.4	91.7	92.4

**Table 7.24. Simulation results scenario S11.2**

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.1	
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.6	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	93.1	84.3	87.0	93.0	95.2	96.3	91.3	96.8	62.8	83.7	93.3	85.5	95.3	95.2	
	2008	86.2	78.6	71.7	92.8	95.5	95.7	86.8	97.0	11.7	64.6	83.2	73.4	89.9	92.6	
	2010	86.5	78.0	62.7	93.0	96.8	96.6	85.8	98.2	11.7	52.0	77.6	66.8	87.8	92.6	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	
	2004	94.7	94.8	95.9	104.4	99.4	96.5	97.4	100.6	96.1	94.7	94.2	97.4	97.9	97.1	
	2008	90.8	94.3	95.3	103.7	98.8	96.6	95.0	100.7	93.7	91.6	89.6	98.0	96.0	96.3	
	2010	90.3	94.3	93.9	103.9	100.1	97.1	94.3	101.0	93.4	89.0	86.6	97.7	94.7	96.1	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	
	2004	101.5	103.0	102.4	109.2	111.0	112.1	101.6	111.1	101.7	102.5	102.4	100.3	106.8	101.5	
	2008	102.1	104.5	103.6	109.0	111.0	112.8	102.5	111.5	103.4	103.5	104.3	100.8	109.0	102.7	
	2010	102.3	104.6	103.4	109.0	111.2	113.1	102.8	111.6	103.5	103.4	104.2	100.4	109.3	102.8	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	96.3	97.4	99.5	100.3	100.1	98.7	99.6	100.4	97.9	99.2	97.8	98.7	96.2	98.5	
	2008	93.8	97.2	99.6	100.3	100.2	98.8	98.8	100.5	96.3	98.2	94.9	98.7	93.0	97.3	
	2010	93.4	97.3	99.7	100.3	100.3	98.9	98.5	100.5	95.9	97.8	93.4	98.8	92.0	97.1	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	104.3	98.3	98.7	105.2	102.8	97.3	98.8	100.5	97.1	96.9	103.2	99.3	99.6	99.5	
	2008	96.6	93.2	93.4	96.6	96.7	93.7	92.9	95.0	91.3	90.4	97.5	94.7	93.9	93.4	
	2010	97.2	93.2	92.3	92.7	97.5	94.4	91.0	93.3	92.5	87.5	95.4	92.6	92.7	92.4	

Table 7.25. Simulation results scenario S11.3

Variable	year	Country										EU-15				
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A		P	FIN	S	UK
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	102.3
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.6	102.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	93.8	85.8	89.2	93.1	96.2	97.0	92.7	97.2	67.1	87.3	94.6	87.8	95.9	96.2	95.2
	2008	87.1	80.4	75.0	92.9	96.6	96.5	89.1	97.5	11.7	70.1	85.5	76.1	90.7	93.7	92.3
	2010	87.5	79.8	66.3	93.1	97.9	97.4	88.4	98.7	11.7	58.1	80.3	69.6	88.7	93.8	92.1
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	94.9	95.0	96.2	104.4	100.3	96.8	97.9	100.7	96.3	95.3	94.7	97.5	98.1	97.4	97.4
	2008	91.2	94.5	95.7	103.8	99.9	97.0	95.9	100.8	94.1	92.7	90.6	98.1	96.3	96.7	96.6
	2010	90.8	94.6	94.4	103.9	101.2	97.5	95.4	101.1	93.4	90.3	87.9	97.9	95.1	96.5	96.4
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	101.6	103.0	102.4	109.2	111.2	112.3	101.5	111.2	101.8	102.7	102.5	100.4	106.8	101.6	106.0
	2008	102.3	104.5	103.7	109.0	111.2	113.1	102.2	111.6	103.4	103.7	104.4	100.9	109.0	102.9	107.0
	2010	102.5	104.6	103.5	109.0	111.4	113.3	102.4	111.7	103.5	103.6	104.4	100.5	109.3	103.1	107.0
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	96.3	97.4	99.5	100.3	100.1	98.7	99.7	100.4	98.0	99.2	97.9	98.7	96.2	98.5	99.2
	2008	94.0	97.2	99.7	100.3	100.3	98.8	99.0	100.5	96.4	98.3	95.1	98.7	93.1	97.4	98.9
	2010	93.6	97.3	99.8	100.3	100.4	99.0	98.8	100.6	96.0	98.0	93.7	98.9	92.1	97.2	98.9
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	104.5	98.4	98.8	105.3	103.5	97.6	99.1	100.6	97.1	97.1	103.7	99.3	99.6	99.6	99.1
	2008	96.9	93.3	93.6	96.6	97.6	94.0	93.5	95.0	91.4	91.0	98.6	94.7	94.0	93.6	93.9
	2010	97.5	93.3	92.5	92.8	98.2	94.6	91.6	93.4	92.6	88.0	96.5	92.7	92.8	92.6	93.4

**Table 7.26. Simulation results scenario S11.4**

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	100.0	100.0	100.0	109.0	108.6	100.0	102.8	105.5	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.4	101.2	101.4	109.2	108.9	101.3	102.8	105.7	101.3	101.0	101.6	101.3	101.4	101.5	102.3
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.2	101.8	101.5	101.5	101.6	102.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	94.7	88.0	92.1	93.2	97.6	98.0	94.6	97.8	73.7	92.4	96.4	91.0	96.8	97.4	96.6
	2008	88.4	82.9	79.5	93.0	98.2	97.6	92.2	98.1	18.7	77.7	88.9	79.9	91.8	95.3	94.1
	2010	88.9	82.3	71.2	93.2	99.5	98.5	92.1	99.4	11.7	66.7	84.4	73.4	89.9	95.4	93.9
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
	2010	101.5	101.4	101.5	109.2	108.9	101.4	102.8	105.7	101.5	101.3	101.8	101.5	101.5	101.6	102.4
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	95.3	95.3	96.5	104.5	101.5	97.4	98.5	100.8	96.5	96.2	95.3	97.6	98.3	97.8	97.8
	2008	91.9	94.9	96.3	103.9	101.5	97.6	97.1	100.9	94.7	94.2	92.1	98.3	96.6	97.2	97.3
	2010	91.6	95.0	95.0	104.0	102.9	98.1	96.9	101.2	93.5	92.0	89.7	98.1	95.5	97.1	97.1
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	101.7	103.1	102.5	109.3	111.4	112.6	101.3	111.2	101.8	102.8	102.6	100.5	106.9	101.9	106.2
	2008	102.5	104.5	103.8	109.0	111.4	113.4	101.8	111.6	103.5	104.0	104.6	101.0	109.1	103.2	107.2
	2010	102.7	104.6	103.6	109.1	111.7	113.7	101.9	111.7	103.5	103.9	104.6	100.7	109.3	103.4	107.2
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	96.4	97.4	99.5	100.3	100.2	98.8	99.8	100.5	98.0	99.3	97.9	98.7	96.3	98.5	99.3
	2008	94.2	97.3	99.7	100.3	100.4	98.9	99.4	100.5	96.6	98.5	95.4	98.7	93.3	97.5	99.0
	2010	93.9	97.4	99.8	100.3	100.5	99.1	99.2	100.6	96.1	98.2	94.3	98.9	92.3	97.4	99.0
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	104.8	98.5	99.0	105.3	104.4	97.9	99.5	100.7	97.3	97.6	104.4	99.4	99.7	99.7	99.4
	2008	97.4	93.5	93.9	96.7	98.8	94.3	94.4	95.1	91.7	91.7	100.2	94.8	94.1	93.8	94.3
	2010	98.0	93.4	92.7	92.8	99.1	94.9	92.5	93.5	92.6	88.7	98.2	92.7	92.9	92.8	93.7

APPENDIX 3

Simulation results: Agenda 2000 plus quota abolition

Table 7.27. Simulation results scenario S20

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	102.5	103.8	108.6	113.1	118.1	111.4	106.8	100.8	114.7	101.3	106.1	101.0	99.6	120.6	109.9
	2010	105.0	109.3	115.2	114.4	118.9	121.8	108.8	100.8	117.4	101.9	108.5	101.4	100.4	129.6	115.3
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	80.0	64.6	13.4	89.8	86.9	85.3	69.2	96.0	11.7	26.7	68.3	55.2	87.3	81.2	77.8
	2010	74.5	57.2	2.8	89.1	88.0	77.2	63.0	97.4	11.7	8.8	59.0	51.0	84.9	79.8	72.9
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	105.0	108.5	112.8	108.7	112.4	116.6	110.0	105.3	121.1	101.4	110.5	101.4	102.4	122.0	113.4
	2010	107.5	113.7	118.1	109.6	112.8	123.9	111.7	105.2	123.7	101.8	112.6	101.6	103.1	128.3	117.6
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	88.5	94.6	96.3	105.9	92.8	97.5	90.6	96.4	106.1	84.5	86.0	96.6	93.5	104.6	96.8
	2010	87.9	98.4	97.5	106.7	94.0	100.1	88.8	96.7	109.6	81.0	82.4	96.7	92.8	109.7	98.4
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	104.2	111.5	113.9	108.4	114.2	120.6	110.1	107.2	127.4	102.6	113.4	99.8	109.4	121.9	115.7
	2010	106.2	117.4	119.0	109.1	114.9	123.6	112.5	107.1	130.6	102.6	115.6	99.7	110.3	128.1	118.9
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.9	96.9	100.6	100.4	100.3	99.5	97.4	99.9	98.5	97.5	94.4	98.6	92.6	99.2	99.3
	2010	92.6	98.0	102.4	100.4	100.5	101.3	96.9	99.9	100.9	96.8	93.2	98.7	91.5	101.7	100.3
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	72.2	79.9	80.6	80.1	68.7	81.0	77.6	73.4	87.2	71.9	56.4	76.7	76.6	83.0	79.3
	2010	72.5	83.5	83.5	80.7	69.3	85.4	77.3	73.6	89.5	70.8	53.7	76.8	76.8	87.2	81.7

**Table 7.28. Simulation results scenario S20y**

Variable	year	Country														EU-15	
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK		
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	96.6	97.9	108.4	110.5	97.4	100.8	100.4	100.3	98.7	99.1	98.6	96.6	101.0	99.5	
	2008	98.0	103.9	105.8	112.4	118.4	109.7	105.9	102.6	114.9	100.1	104.9	101.2	99.7	121.7	108.9	
	2010	101.7	115.2	115.5	117.8	122.1	124.2	111.7	107.1	117.6	103.7	109.2	105.2	103.9	136.7	118.0	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	93.2	79.6	87.6	94.0	88.8	94.4	85.0	95.6	36.0	70.3	86.8	81.7	94.5	89.3	90.6	
	2008	91.0	66.1	49.8	91.2	87.0	87.6	71.6	96.1	11.7	51.3	69.3	71.1	88.6	81.0	81.9	
	2010	86.6	52.2	2.8	88.3	87.6	77.1	63.0	96.0	11.7	19.6	58.9	38.7	83.5	77.9	73.0	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2	
	2008	105.8	114.3	116.5	113.9	118.5	121.5	114.9	111.8	127.7	106.1	115.2	106.9	108.0	129.3	118.6	
	2010	112.6	129.0	127.9	121.0	123.4	135.7	123.5	117.4	133.9	111.2	122.4	112.2	114.8	144.0	129.1	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5	
	2004	92.7	90.9	93.7	104.7	94.4	93.6	94.3	96.2	95.3	90.6	91.5	95.6	94.6	96.0	94.4	
	2008	90.4	94.9	98.1	106.4	93.0	97.9	91.1	97.9	106.4	88.3	85.7	97.8	94.1	105.2	97.7	
	2010	91.8	103.2	99.5	110.5	94.6	102.1	90.9	101.6	109.8	86.6	82.8	100.7	95.6	113.5	101.1	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0	
	2004	98.8	99.9	99.7	107.0	107.3	109.4	100.1	105.2	98.7	99.1	99.1	98.6	104.2	97.9	102.6	
	2008	102.1	111.4	112.2	108.1	114.2	120.7	109.0	108.1	127.6	102.0	112.2	100.8	109.7	122.7	115.4	
	2010	106.9	124.8	120.7	112.5	118.0	126.6	115.4	114.3	132.5	105.7	118.1	102.1	114.4	135.0	122.5	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	95.6	96.6	99.0	100.2	99.7	98.1	98.7	99.9	97.8	98.8	97.4	98.4	95.7	98.3	98.8	
	2008	92.5	96.6	100.0	100.3	100.1	99.0	97.2	99.9	98.7	97.1	93.6	98.3	92.2	98.8	98.9	
	2010	92.4	98.4	101.9	100.4	100.6	101.2	97.0	100.3	101.1	96.6	92.3	99.0	91.4	101.8	100.3	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	90.3	94.6	95.2	100.8	93.4	90.6	92.2	93.4	94.4	92.1	92.6	96.0	95.6	95.4	93.5	
	2008	74.2	83.4	83.8	83.2	72.6	83.8	80.1	77.5	91.0	76.0	61.3	80.2	80.0	87.8	82.8	
	2010	77.0	93.2	89.9	87.9	74.7	92.0	83.2	80.3	95.0	77.5	60.2	84.1	84.3	96.8	88.5	

**Table 7.29. Simulation results scenario S20-80**

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	97.8	100.6	105.9	110.8	116.6	107.0	104.0	98.3	113.6	99.4	104.8	97.9	96.8	116.7	106.8
	2010	93.7	103.1	111.2	110.4	117.0	113.4	104.0	97.3	116.6	98.3	106.5	96.9	96.5	123.7	110.3
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	86.6	68.3	28.1	91.0	87.1	88.0	71.2	96.7	11.7	37.6	68.8	77.8	89.4	82.2	80.7
	2010	94.0	64.9	2.8	91.5	88.3	83.4	67.2	98.6	11.7	36.1	59.9	94.9	88.5	81.1	77.3
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	98.4	103.7	108.5	105.4	110.0	110.8	105.4	102.1	117.5	98.9	107.7	97.0	97.5	116.9	108.9
	2010	94.2	106.1	112.8	105.2	110.2	115.3	105.5	101.5	120.4	98.3	109.2	96.4	97.2	121.7	111.6
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	87.5	92.1	94.9	104.1	92.5	96.0	89.6	94.5	105.0	83.9	85.4	94.2	91.6	102.5	95.4
	2010	87.2	93.7	94.0	104.0	93.7	97.9	87.5	94.2	108.5	81.7	81.6	93.9	90.5	106.4	96.1
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	98.9	106.4	109.8	105.6	111.7	117.2	106.5	102.9	122.7	99.8	110.2	98.0	105.2	116.8	111.7
	2010	96.7	109.1	113.5	105.5	112.1	119.2	107.3	101.6	126.8	98.8	111.7	98.4	105.4	121.6	113.8
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.4	96.5	100.2	100.3	100.2	99.0	97.2	99.7	97.7	97.3	94.3	98.1	92.3	98.8	98.9
	2010	91.4	97.0	101.3	100.3	100.4	100.2	96.5	99.7	100.2	96.4	92.7	97.8	90.9	100.7	99.6
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	69.8	76.8	78.2	78.0	68.3	78.0	75.4	72.2	85.5	70.7	56.4	73.6	73.4	80.5	77.1
	2010	68.2	78.4	80.0	77.8	68.9	80.8	74.5	72.2	87.7	69.7	53.6	73.1	73.0	83.7	78.5

**Table 7.30. Simulation results scenario S20-60**

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	96.6	97.9	108.4	110.5	97.4	100.8	100.4	100.3	98.7	99.1	98.6	96.6	101.0	99.5
	2008	104.4	108.3	109.5	115.5	120.4	115.7	109.7	106.0	115.3	102.7	106.8	105.4	103.5	127.0	113.0
	2010	117.6	124.1	121.6	123.4	124.8	135.9	118.4	111.9	118.0	108.6	112.0	111.5	109.4	145.1	125.1
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	93.2	79.6	87.6	94.0	88.8	94.4	85.0	95.6	36.0	70.3	86.8	81.7	94.5	89.3	90.6
	2008	82.0	61.2	29.9	89.6	86.7	83.9	68.9	95.2	11.7	36.7	68.7	40.6	85.8	79.8	78.1
	2010	59.8	41.6	2.8	85.1	87.3	68.6	57.1	94.4	11.7	7.8	57.5	7.8	78.5	76.1	67.2
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	115.3	121.2	122.6	118.5	121.9	129.8	121.4	116.4	131.7	109.6	119.2	113.0	115.0	136.6	124.9
	2010	132.6	140.5	136.3	127.5	127.2	148.5	132.9	122.8	137.9	116.4	127.5	119.9	123.7	153.8	138.0
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.7	90.9	93.7	104.7	94.4	93.6	94.3	96.2	95.3	90.6	91.5	95.6	94.6	96.0	94.4
	2008	91.8	98.3	100.0	108.9	93.3	99.9	92.6	100.5	107.0	89.1	86.5	101.2	96.8	108.1	99.7
	2010	93.0	109.8	103.2	114.3	95.0	105.2	92.9	105.1	110.3	85.8	84.0	104.8	99.0	118.3	104.0
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	98.8	99.9	99.7	107.0	107.3	109.4	100.1	105.2	98.7	99.1	99.1	98.6	104.2	97.9	102.6
	2008	109.2	118.3	117.7	111.8	117.6	125.3	113.9	113.9	131.9	105.7	116.5	103.2	115.4	129.7	120.6
	2010	120.5	136.6	128.4	117.6	121.7	132.8	122.6	122.0	136.8	111.0	123.5	104.0	121.3	144.1	129.5
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.6	96.6	99.0	100.2	99.7	98.1	98.7	99.9	97.8	98.8	97.4	98.4	95.7	98.3	98.8
	2008	93.1	97.2	100.6	100.4	100.2	99.7	97.5	100.1	99.1	97.3	93.9	98.9	92.5	99.3	99.3
	2010	94.0	99.8	103.3	100.6	100.8	102.8	97.5	100.7	101.4	97.2	92.9	100.2	92.1	103.2	101.2
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.3	94.6	95.2	100.8	93.4	90.6	92.2	93.4	94.4	92.1	92.6	96.0	95.6	95.4	93.5
	2008	77.7	87.8	87.2	86.1	73.2	88.1	83.2	79.3	92.8	77.6	61.6	84.5	84.6	91.4	86.0
	2010	83.9	100.9	95.0	92.1	75.4	98.9	87.6	82.4	96.8	79.2	60.6	89.5	90.0	102.1	93.2

**Table 7.31. Simulation results scenario S21**

Variable	year	Country										Country				
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	98.0	100.5	105.8	110.7	116.4	106.9	103.8	98.0	113.4	99.3	104.6	97.6	96.5	116.4	106.7
	2010	92.1	101.5	109.9	109.1	116.0	111.2	102.4	95.7	116.7	97.4	105.6	95.0	94.7	121.4	108.8
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	85.9	67.9	26.5	90.9	87.1	87.9	71.0	96.6	11.7	36.0	68.8	75.1	89.2	82.1	80.4
	2010	95.5	66.2	2.8	92.0	88.4	84.5	68.0	98.9	11.7	39.1	60.1	104.1	89.4	81.5	78.0
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	97.2	102.5	107.1	104.3	108.8	108.9	103.9	100.7	115.7	98.0	106.4	95.2	95.6	115.0	107.3
	2010	90.5	102.8	109.6	102.6	107.9	110.9	101.9	98.8	117.9	96.3	106.8	92.7	93.1	117.6	108.2
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	87.0	91.9	94.4	103.8	92.4	95.7	89.3	94.3	104.9	83.4	85.3	93.6	91.2	102.2	95.0
	2010	86.2	92.5	92.8	102.8	93.5	96.8	86.7	92.9	108.6	80.9	81.1	92.1	89.1	105.1	95.1
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	97.6	105.2	108.4	104.6	110.5	115.7	105.4	101.9	120.8	98.9	108.9	97.0	103.6	115.0	110.3
	2010	93.3	105.7	110.3	103.3	109.9	116.3	104.7	98.4	124.0	96.7	109.0	96.6	101.9	117.5	110.8
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.5	96.6	100.2	100.3	100.2	99.0	97.2	99.8	97.8	97.3	94.3	98.1	92.4	98.9	99.0
	2010	91.3	96.9	101.1	100.3	100.4	100.0	96.4	99.6	100.3	96.3	92.7	97.6	90.9	100.6	99.5
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	59.1	63.4	63.4	65.0	54.2	65.1	65.1	60.4	71.1	59.1	37.5	60.4	60.3	64.0	63.5
	2010	55.2	60.9	60.7	61.5	51.6	63.7	61.3	57.6	69.9	55.3	30.4	56.3	56.2	62.2	61.0

**Table 7.32. Simulation results scenario S21y**

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	96.6	97.9	108.4	110.5	97.4	100.8	100.4	100.3	98.7	99.1	98.6	96.6	101.0	99.5
	2008	98.4	103.9	105.7	112.2	118.1	109.6	105.6	102.1	115.1	100.0	104.7	100.7	99.2	121.2	108.8
	2010	98.5	112.0	112.6	115.1	120.0	119.7	108.4	103.6	117.8	101.7	107.5	101.2	100.0	131.8	114.7
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	93.2	79.6	87.6	94.0	88.8	94.4	85.0	95.6	36.0	70.3	86.8	81.7	94.5	89.3	90.6
	2008	89.3	65.1	45.8	90.9	86.9	87.1	71.2	95.9	11.7	47.5	69.2	64.6	88.0	80.8	81.2
	2010	89.0	54.7	2.8	89.3	87.9	79.1	64.5	96.6	11.7	24.7	59.3	55.9	85.2	78.9	74.3
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	103.6	112.0	113.5	111.6	116.0	117.8	111.9	109.1	124.6	104.2	112.8	103.1	104.2	125.7	115.5
	2010	103.9	121.1	119.8	114.7	117.9	125.2	114.9	110.5	127.5	106.3	116.5	103.0	104.7	134.0	120.7
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.7	90.9	93.7	104.7	94.4	93.6	94.3	96.2	95.3	90.6	91.5	95.6	94.6	96.0	94.4
	2008	89.5	94.7	97.2	105.8	92.8	97.2	90.7	97.5	106.7	87.4	85.4	96.9	93.4	104.8	97.2
	2010	89.5	100.5	96.9	107.9	94.1	99.8	89.3	98.8	110.1	84.8	81.8	96.8	92.6	110.7	98.9
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	98.8	99.9	99.7	107.0	107.3	109.4	100.1	105.2	98.7	99.1	99.1	98.6	104.2	97.9	102.6
	2008	99.6	109.2	109.4	106.2	111.9	117.9	107.1	106.2	124.3	100.3	109.7	99.0	106.6	119.4	112.7
	2010	99.4	117.3	113.4	107.5	112.7	119.8	109.3	107.4	125.9	101.0	111.9	98.1	106.3	125.7	115.4
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.6	96.6	99.0	100.2	99.7	98.1	98.7	99.9	97.8	98.8	97.4	98.4	95.7	98.3	98.8
	2008	92.6	96.7	100.0	100.3	100.2	99.1	97.3	99.9	98.9	97.2	93.7	98.4	92.3	98.9	99.0
	2010	92.1	98.2	101.5	100.4	100.5	100.9	96.9	100.1	101.3	96.5	92.2	98.6	91.2	101.7	100.1
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.3	94.6	95.2	100.8	93.4	90.6	92.2	93.4	94.4	92.1	92.6	96.0	95.6	95.4	93.5
	2008	65.0	71.5	70.7	71.8	60.6	72.1	70.8	67.0	78.6	65.8	45.8	67.8	67.7	73.1	70.7
	2010	57.8	66.6	62.5	64.4	51.7	66.8	63.8	59.6	70.7	57.4	29.8	58.9	58.9	65.5	63.4

**Table 7.33. Simulation results scenario S21-80**

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	96.2	99.3	104.8	109.8	115.9	105.3	102.8	97.2	111.0	98.6	104.2	96.6	95.6	115.1	105.4
	2010	88.3	99.6	108.3	108.0	115.5	108.6	101.0	94.8	115.9	96.3	105.1	93.8	93.7	119.7	107.1
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	88.5	69.3	32.2	91.4	87.2	88.9	71.8	96.9	11.7	40.3	69.0	83.9	90.0	82.4	81.5
	2010	102.2	68.7	2.8	92.7	88.5	86.5	69.4	99.2	11.7	48.3	60.5	117.9	90.5	81.9	79.4
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	95.0	101.0	105.8	103.3	108.2	107.2	102.6	99.8	112.8	97.3	105.7	94.0	94.2	113.6	105.9
	2010	86.5	100.7	108.0	101.5	107.5	108.7	100.4	98.0	116.8	95.4	106.0	91.6	91.8	116.1	106.6
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	86.8	91.0	94.1	103.2	92.3	95.2	89.0	93.6	102.6	83.3	85.1	92.9	90.6	101.5	94.5
	2010	86.1	91.0	92.7	102.0	93.4	96.2	86.4	92.2	107.7	81.3	80.9	91.5	88.5	104.2	94.6
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	96.0	103.6	107.2	103.9	109.8	114.8	104.3	100.5	117.3	98.1	108.0	96.6	102.4	113.5	109.0
	2010	90.5	103.4	108.9	102.4	109.3	115.3	103.3	97.1	122.6	95.8	108.2	96.5	100.9	116.0	109.5
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.3	96.4	100.0	100.3	100.2	98.9	97.1	99.7	97.5	97.3	94.2	97.9	92.3	98.8	98.9
	2010	90.9	96.5	100.8	100.3	100.3	99.6	96.3	99.5	99.6	96.2	92.5	97.3	90.7	100.3	99.2
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	62.6	67.6	68.4	69.4	59.7	69.2	68.4	64.6	74.8	63.3	45.1	64.4	64.3	69.7	67.9
	2010	58.1	64.8	65.9	65.8	57.3	67.7	64.6	61.9	74.9	59.7	38.2	60.3	60.2	68.1	65.7

**Table 7.34. Simulation results scenario S21-60**

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	99.6	101.5	107.3	111.4	116.8	108.7	104.7	98.7	114.3	99.9	105.0	98.4	97.2	120.9	108.3
	2010	94.9	102.7	112.4	109.7	116.1	114.7	103.2	96.0	117.2	98.1	105.8	95.5	95.0	130.1	111.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	83.3	66.4	18.5	90.5	87.1	86.6	70.2	96.4	11.7	31.4	68.5	66.1	88.4	81.2	79.0
	2010	89.8	64.4	2.8	91.4	88.4	81.9	67.0	98.6	11.7	31.6	59.9	94.3	88.7	79.7	76.2
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	98.8	103.4	109.7	104.8	108.9	111.3	104.7	101.1	116.5	98.3	106.7	95.6	96.2	122.4	109.6
	2010	92.9	103.4	113.4	102.6	107.5	114.5	102.0	98.4	117.6	96.3	106.5	92.3	92.7	129.1	111.2
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	87.0	92.7	95.2	104.2	92.5	96.2	89.6	94.8	105.8	83.4	85.4	94.2	91.6	104.8	95.8
	2010	85.8	93.3	95.0	103.0	93.4	97.7	86.8	93.0	109.2	80.2	81.2	92.1	89.1	110.1	96.4
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	98.7	106.3	110.9	105.0	110.7	117.0	106.1	102.8	122.0	99.3	109.3	97.1	104.2	122.3	112.4
	2010	94.6	106.5	114.2	103.2	109.5	118.1	104.9	98.5	123.7	96.8	108.8	96.1	101.5	128.9	113.6
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.6	96.8	100.5	100.4	100.2	99.3	97.3	99.8	98.2	97.4	94.4	98.3	92.5	99.3	99.1
	2010	91.6	97.2	101.7	100.3	100.4	100.5	96.5	99.6	100.7	96.4	92.8	97.7	91.0	101.8	99.9
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	53.9	57.0	56.7	58.6	46.5	59.4	60.1	54.3	64.2	53.1	27.1	54.1	54.1	57.2	57.1
	2010	49.1	52.9	52.7	53.6	42.6	56.8	55.1	50.2	61.0	47.9	18.0	48.4	48.4	54.3	53.4

**Table 7.35. Simulation results scenario S22**

Variable	year	Country							Country							EU-15	
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK		
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1	
	2008	100.7	102.4	107.3	112.0	117.3	109.4	105.5	99.5	114.5	100.4	105.4	99.4	98.1	118.6	108.5	
	2010	98.6	105.1	112.1	111.4	117.0	116.0	105.1	97.6	117.3	99.4	106.8	97.5	96.9	124.7	111.6	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9	
	2008	82.0	65.7	17.7	90.2	87.0	86.2	69.8	96.2	11.7	29.5	68.4	61.6	87.9	81.5	78.7	
	2010	84.2	61.8	2.8	90.6	88.2	80.9	65.6	98.2	11.7	23.3	59.6	78.8	87.4	80.8	75.5	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.1	101.2		
	2008	101.0	105.2	109.5	106.1	110.1	112.2	106.5	102.5	118.1	99.4	108.0	97.6	98.4	118.0	109.9	
	2010	98.1	107.0	112.4	105.0	109.3	115.7	105.4	100.7	119.8	98.2	108.6	95.5	96.3	121.2	111.5	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5	
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9	
	2008	87.5	93.4	95.2	104.8	92.6	96.5	89.9	95.4	106.0	83.7	85.6	95.0	92.3	103.5	95.9	
	2010	86.5	95.1	94.8	104.3	93.6	98.1	87.5	94.3	109.4	80.4	81.6	93.7	90.4	107.0	96.4	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0	
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0	
	2008	100.6	108.1	110.7	106.2	111.9	117.6	107.5	104.3	124.0	100.5	110.7	98.0	106.0	117.9	112.6	
	2010	98.7	110.3	113.3	105.2	111.3	118.7	107.5	101.5	126.1	98.8	111.1	97.3	104.6	121.0	113.5	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9	
	2008	92.8	96.8	100.5	100.4	100.2	99.3	97.3	99.9	98.4	97.4	94.4	98.4	92.5	99.1	99.2	
	2010	91.9	97.5	101.7	100.4	100.5	100.6	96.6	99.7	100.8	96.5	92.9	98.1	91.2	101.2	99.9	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2	
	2008	63.7	69.3	69.3	70.2	59.0	70.7	69.4	64.8	76.8	63.4	43.7	66.0	65.9	70.5	68.9	
	2010	59.8	67.1	66.5	66.5	55.9	69.5	65.4	61.5	74.9	59.0	35.9	61.5	61.4	68.5	66.4	

Table 7.36. Simulation results scenario S22y

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	96.6	97.9	108.4	110.5	97.4	100.8	100.4	100.3	98.7	99.1	98.6	96.6	101.0	99.5
	2008	100.5	105.3	106.9	113.3	118.8	111.6	106.9	103.3	115.3	100.9	105.3	102.1	100.5	123.0	110.1
	2010	104.0	115.2	115.1	117.2	121.1	124.0	110.9	105.5	117.9	103.5	108.6	103.6	102.2	135.0	117.4
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	93.2	79.6	87.6	94.0	88.8	94.4	85.0	95.6	36.0	70.3	86.8	81.7	94.5	89.3	90.6
	2008	86.5	63.6	39.7	90.4	86.9	85.9	70.3	95.6	11.7	43.1	69.0	55.2	87.1	80.4	80.0
	2010	79.9	51.0	2.8	88.1	87.7	76.1	62.4	96.0	11.7	12.0	58.8	34.3	83.4	78.2	72.2
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	106.9	114.5	115.8	113.3	117.4	120.9	114.4	110.9	126.2	105.5	114.3	105.5	106.9	128.4	117.9
	2010	111.2	125.5	123.5	117.4	119.6	130.2	118.7	112.9	129.4	108.4	118.6	106.3	108.5	138.1	124.3
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.7	90.9	93.7	104.7	94.4	93.6	94.3	96.2	95.3	90.6	91.5	95.6	94.6	96.0	94.4
	2008	90.0	95.9	97.9	106.7	93.0	98.0	91.2	98.4	106.9	87.8	85.8	98.1	94.4	105.8	97.9
	2010	90.1	102.9	97.7	109.4	94.3	101.1	90.1	100.3	110.2	84.6	82.3	98.5	94.0	112.6	99.9
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	98.8	99.9	99.7	107.0	107.3	109.4	100.1	105.2	98.7	99.1	99.1	98.6	104.2	97.9	102.6
	2008	102.2	111.7	111.5	107.6	113.3	119.7	108.9	108.3	126.0	101.7	111.4	100.0	108.8	122.0	114.7
	2010	104.5	121.8	116.6	109.6	114.4	122.4	112.2	110.5	127.8	103.1	114.2	99.0	109.3	129.4	118.3
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.6	96.6	99.0	100.2	99.7	98.1	98.7	99.9	97.8	98.8	97.4	98.4	95.7	98.3	98.8
	2008	92.8	96.9	100.2	100.3	100.2	99.3	97.4	100.0	99.0	97.2	93.8	98.6	92.4	99.1	99.1
	2010	92.6	98.7	102.0	100.5	100.6	101.5	97.0	100.3	101.3	96.7	92.5	99.0	91.5	102.1	100.4
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.3	94.6	95.2	100.8	93.4	90.6	92.2	93.4	94.4	92.1	92.6	96.0	95.6	95.4	93.5
	2008	69.7	77.6	76.9	77.2	65.8	78.0	75.3	71.8	84.1	70.4	52.6	73.7	73.7	80.1	76.4
	2010	63.6	74.6	69.9	70.9	57.4	74.0	69.2	64.9	76.9	62.5	37.3	65.7	65.7	74.0	70.3

**Table 7.37. Simulation results scenario S23**

Variable	year	Country								Country						
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	99.9	98.0	99.9	110.2	111.9	99.2	102.5	101.6	100.3	100.1	100.5	100.1	98.0	102.5	101.1
	2008	93.9	97.8	103.5	108.7	115.3	103.2	101.5	96.0	107.8	97.8	103.6	95.2	94.3	113.3	103.8
	2010	83.3	97.0	106.3	106.4	114.9	105.3	99.2	93.7	112.0	94.9	104.4	92.2	92.4	117.6	104.8
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	90.1	77.7	76.1	93.0	88.6	93.2	83.6	95.2	36.0	60.9	86.2	69.0	93.2	88.9	88.9
	2008	91.9	71.2	39.8	92.0	87.3	90.3	72.8	97.3	11.7	46.0	69.2	95.7	91.0	82.9	83.0
	2010	111.1	72.0	9.0	93.7	88.6	89.2	71.2	99.7	11.7	60.5	60.9	136.4	92.0	82.4	81.7
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	100.6
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	101.2
	2008	92.2	99.0	104.2	102.1	107.4	105.0	100.9	98.7	109.0	96.4	104.7	92.5	92.4	111.7	103.9
	2010	81.2	98.0	106.1	100.2	106.9	105.9	98.5	97.1	112.7	94.4	105.1	90.3	90.3	114.3	104.4
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	99.5
	2004	92.6	91.9	94.4	105.9	94.6	94.1	94.8	97.1	95.3	90.8	92.1	96.7	95.5	96.7	94.9
	2008	86.5	89.9	93.5	102.4	92.2	94.6	88.6	92.8	99.5	83.2	84.8	91.8	89.7	100.5	93.7
	2010	86.1	89.2	92.5	101.1	93.3	95.5	86.0	91.4	103.8	81.9	80.6	90.7	87.8	103.0	93.8
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	103.0
	2004	100.5	102.5	102.1	109.3	110.2	110.8	102.2	108.4	101.6	101.8	102.0	99.5	106.3	100.5	105.0
	2008	93.9	101.5	105.7	102.9	109.0	113.6	102.9	98.8	112.7	97.1	106.9	96.0	100.9	111.6	107.3
	2010	87.0	100.4	107.1	101.4	108.7	114.1	101.7	95.4	117.4	94.6	107.2	96.4	99.6	114.2	107.7
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	95.8	96.8	99.3	100.2	99.8	98.3	98.9	100.1	97.8	99.0	97.6	98.7	95.9	98.4	98.9
	2008	92.1	96.2	99.8	100.3	100.1	98.6	97.0	99.6	97.0	97.2	94.1	97.7	92.1	98.6	98.7
	2010	90.4	96.1	100.4	100.2	100.3	99.2	96.2	99.4	98.3	96.0	92.3	96.9	90.4	99.8	98.9
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	89.7	94.6	95.0	100.9	92.1	90.5	92.2	92.7	94.0	91.8	90.5	96.1	95.7	94.9	93.2
	2008	55.1	58.0	58.1	60.3	50.1	60.1	61.2	56.5	63.7	55.4	32.2	55.3	55.2	58.2	58.3
	2010	51.9	56.1	56.9	58.0	49.1	59.4	58.4	55.2	64.5	53.3	27.2	52.7	52.7	57.9	57.2

**Table 7.38. Simulation results scenario S23y**

Variable	year	Country														
		B	DK	GER	GR	SP	FR	IRL	IT	NL	A	P	FIN	S	UK	EU-15
stock dairy	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	2004	97.9	96.6	97.9	108.4	110.5	97.4	100.8	100.4	100.3	98.7	99.1	98.6	96.6	101.0	
	2008	94.1	101.0	103.3	110.2	116.9	105.7	103.1	100.0	114.7	98.4	103.6	98.1	96.8	117.9	
	2010	88.9	107.0	108.7	112.2	118.8	113.3	104.9	101.4	117.5	99.0	106.1	98.1	97.5	127.7	
stock suckler	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	93.2	79.6	87.6	94.0	88.8	94.4	85.0	95.6	36.0	70.3	86.8	81.7	94.5	89.3	
	2008	95.6	68.6	59.7	92.0	87.1	89.7	73.0	96.6	11.7	58.1	69.7	86.1	89.9	81.7	
	2010	105.9	61.0	12.4	91.2	88.0	84.2	67.9	97.5	11.7	47.7	60.1	90.7	88.0	79.8	
q milk	2000	100.0	100.0	100.0	104.6	104.5	100.0	101.4	102.9	100.0	100.0	100.0	100.0	100.0	100.1	
	2004	100.0	100.0	100.0	109.2	108.9	100.0	102.8	105.7	100.0	100.0	100.0	100.0	100.0	100.1	
	2008	98.0	108.1	110.3	109.2	114.5	113.4	108.5	106.9	122.8	102.4	110.8	100.1	100.6	121.9	
	2010	93.0	115.5	116.0	112.0	116.8	119.5	111.0	108.8	126.5	104.2	114.7	100.4	101.6	130.2	
q beef & veal	2000	99.5	99.2	99.2	100.1	100.6	99.7	99.7	98.9	99.3	99.1	99.0	99.6	100.1	99.7	
	2004	92.7	90.9	93.7	104.7	94.4	93.6	94.3	96.2	95.3	90.6	91.5	95.6	94.6	96.0	
	2008	88.9	92.5	96.2	104.3	92.6	96.1	89.9	95.9	106.2	87.1	84.9	95.0	91.8	103.0	
	2010	89.3	96.9	96.5	106.0	94.0	98.4	88.5	97.2	109.6	85.8	81.3	95.2	91.2	108.4	
q feed	2000	101.1	101.5	101.4	105.1	105.6	106.8	100.9	103.7	100.9	101.5	101.4	100.5	103.4	101.2	
	2004	98.8	99.9	99.7	107.0	107.3	109.4	100.1	105.2	98.7	99.1	99.1	98.6	104.2	97.9	
	2008	95.7	105.3	106.6	104.3	110.4	115.6	104.4	103.0	122.4	98.3	107.6	97.9	103.8	115.8	
	2010	92.5	111.6	110.1	105.5	111.6	117.5	106.2	104.2	124.8	98.8	110.0	97.9	103.9	122.1	
land	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	95.6	96.6	99.0	100.2	99.7	98.1	98.7	99.9	97.8	98.8	97.4	98.4	95.7	98.3	
	2008	92.1	96.3	99.6	100.3	100.1	98.7	97.1	99.8	98.6	97.0	93.5	97.9	92.1	98.6	
	2010	91.1	97.3	100.7	100.3	100.4	100.0	96.6	99.9	101.0	96.2	91.9	97.9	90.8	100.8	
gross margin	2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	2004	90.3	94.6	95.2	100.8	93.4	90.6	92.2	93.4	94.4	92.1	92.6	96.0	95.6	95.4	
	2008	60.2	65.1	64.6	66.3	55.9	66.2	66.2	62.5	73.3	61.5	39.7	61.9	61.7	66.2	
	2010	54.4	61.7	59.0	61.1	49.4	62.5	60.9	57.3	68.1	55.6	26.9	55.5	55.5	61.3	

## **8. A SPATIAL EQUILIBRIUM MODEL OF THE EU'S DAIRY INDUSTRY**

### **Agenda 2000 and beyond: Impact of alternative reforms of the Common Market Organisation for milk and dairy products**

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#### **8.1. Introduction**

The objective of this part of the project (i.e., subtask 2.2) was to develop a tool for simulating policy reforms in the dairy industry, with an emphasis on the milk-processing sector, of the European Union.

Over the last few decades, agricultural policy has had a major impact in the European Union (EU). In particular, the EU dairy sector has been greatly influenced by EU policy. With a general objective of increasing farm income, EU dairy policy is rather complex and involves the use of many policy instruments. It includes a price support program (implemented through government purchases) for butter and skim milk powder, import taxes and export subsidies that have been in place since the 1960's. It also includes production quotas since 1984, as well as a lowering of trade barriers following the Uruguay Round trade negotiations in the 1990's. More recently, the Berlin accord set the stage for some reform of the EU dairy policy. Current and future World Trade Organisation (WTO) negotiations suggest further reforms contributing to a greater integration of the EU dairy sector in the world dairy markets.

Since Oskam (1989), there has been few studies focusing on the impact of recent changes in the EU dairy policy (e.g., Benjamin, Gohin and Guyomard, 1999; Bouamra-Mechemache and Réquillart, 1999, 2000). These studies have investigated the economic and welfare effects of various EU dairy policy reforms. However, conducting such analyses raises significant challenges. First, the dairy sector is a multi-product industry, where farm milk is used to produce a variety of differentiated products (e.g., fluid milk, cheese, butter, etc.). With each product being different in terms of storability and market characteristics, this indicates a need for a disaggregated analysis of the dairy sector that would capture the role of its differentiated markets. This is reinforced by the fact that many dairy policy instruments are specific to a particular market (e.g., price support programs for butter and skim milk powder). Second, the allocation of milk to the production of dairy products requires a good understanding of the dairy processing technology (see Chavas, Cox and Jesse, 1998). Of special interest are its implications for the determination of milk and dairy market prices. Third, there are significant differences in production and consumption across states in the EU dairy industry. This

suggests a need to develop an analysis of EU policy reforms that reflects the regional heterogeneity within the EU dairy sector. For example, this would provide useful information on the spatial distribution of welfare effects across regions.

Given these complex issues, previous researches usually rely on simplifying assumptions. Often, the regional differences in production and consumption within the EU are ignored and analysis is carried out at a coarse level of commodity aggregation that does not match well some of the EU domestic and trade policy instruments actually in force. As well, these previous analyses are generally limited to a subset of policy instruments (e.g., production quota and export subsidies). This suggests a need for a more refined analysis of dairy policy reforms in at least three directions: 1/ capturing the regional heterogeneity of the EU dairy sector; 2/ improving our understanding of the interactions between the various differentiated dairy markets and EU domestic and trade policy instruments; and 3/ trying to anticipate how future changes in dairy policy could affect the EU dairy sector.

This part of the project develops a spatial equilibrium model of the EU dairy industry for analysing and assessing the economic and welfare effects of EU dairy policy reforms. The proposed model is based on a spatial market equilibrium framework in the context of a vertical multi-market sector. The modelling of the processing technology relies on allocation of milk components (milk fat and protein) among dairy commodities under a Leontief technology. This provides a framework to investigate commodity prices as well as the shadow prices of the implicit milk components. After incorporating relevant policy instruments, the model solves for milk and dairy commodity prices, productions, consumptions and trade among regions. The model is then used to investigate the economic and welfare impacts of several EU policy scenarios, including the Berlin accord and alternative trade liberalisation schemes. The results provide useful information on the effects of EU policy reform on the efficiency and distribution of welfare across European countries.

This chapter is organised as follows. Section 2 presents the proposed spatial model of the EU dairy industry. Section 3 reports and discusses simulation results. Section 4 concludes and draws some policy recommendations.

## **8.2. The spatial model of the EU dairy industry**

The proposed model is a spatial model of resource allocation in the European Union dairy sector. This section reports the main characteristics of this model. It is described in further details in appendix 1.

The dairy sector is modelled as a vertical structure that includes the supply of milk, the processing of milk into final products and the demand for dairy products. The model considers two agricultural products, and ten final products (butter, skim milk powder (SMP), whole milk powder, condensed milk, fluid milk, fresh products, casein, hard and semi-hard cheese, processed cheese, other cheese).

The EU is divided into nine regions to account for the differences in relative competitiveness of the different EU regions and to better analyse the effects of policy changes on regions' relative competitive positions. The model also considers a "rest of the world" in order to depict trade in dairy products between EU regions and third countries and to better analyse the effects of changes in trade policy instruments (such as export refunds and import tariffs for example).

The main instruments of the Common Market Organisation (CMO) for milk and dairy products are explicitly modelled. This includes milk production quotas, intervention prices (SMP, butter), ceiling quantities for public intervention, consumption subsidies (SMP, butter), production subsidies (casein), export refunds, import tariffs and tariff-rate quotas. The model also takes into account the Uruguay Round commitments in terms of subsidised exports and in terms of market access (current access, minimum access).

For a given policy scenario, the model determines the price and the production of milk and dairy products in the different considered EU regions and at the EU aggregate level. It also solves for the domestic consumption (subsidised and unsubsidised) as well as EU stocks, exports and imports of each dairy product. Finally, the model provides the impacts of policy scenarios on EU farmers' income, on EU taxpayer costs (exports, consumption subsidies, direct transfers) and on EU welfare. Given its structure, the model allows for analysing a great variety of EU dairy policy reforms, including milk quota removal, change in export subsidies as well as in domestic consumption subsidies, changes in the subsidised exports commitments, changes in the minimum and/or current access commitments, etc.

The model is static. It allows for comparisons of the effects of policy scenarios *ceteris paribus*. All the results are presented in terms of changes relative to a reference scenario (index base 100 for the reference scenario). It is assumed that adjustments are completed instantaneously. Elasticities used reflect rather long-term than short term adjustment.

As the model is designed to analyse the impacts of policy scenarios that are sustainable in the long term, we generally assume no public purchase. A policy resulting in public intervention purchases would not be sustainable in the long term since it would lead to accumulation of public stocks. In such a case, further adjustments would be required (such as decreases in intervention prices for example).

Tables 8.1 to 8.3 summarise the model's exogenous and endogenous variables as well as parameters. Policy instruments that are explicitly represented in the model are reported as well. Values assigned to demand and supply elasticities and adopted assumptions regarding the initial levels of the unit quota rents are summarised in appendix 2.

**Table 8.1. Variables and parameters relating to raw milk**

Raw Milk (9 EU regions)	Status of the variable	Comments	Policy Instruments set by the modeller
Supply function			
Supply elasticity	Parameter	Sensitivity analysis	
Initial quota rents	Exogenous	Sensitivity analysis	
Composition of milk	Exogenous		
Quotas	Exogenous		YES
Direct payments	Exogenous	Decoupled or coupled	YES
Farm price	Endogenous		
Milk production	Exogenous; Endogenous*		
Price of milk components	Endogenous		

\* Exogenous when milk production quotas are in force; Endogenous when the quotas are removed.

**Table 8.2. Variables and parameters relating to final dairy products**

Final Products (9 EU regions)	Status of the variable	Comments	Policy Instruments set by the modeller
Unsubsidised demand functions		10 products;	
Demand elasticities	Parameters	Sensitivity analysis	
Subsidised demand functions		Butter, SMP;	
Demand elasticities	Parameters	Sensitivity analysis	
Technical processing coefficients	Parameters	10 products; no difference across regions (except for fluid milk)	
Processing costs	Exogenous	10 products; calibrated	
Intervention prices	Exogenous;	Butter, SMP	YES
Ceilings on public intervention purchase	Exogenous	Butter, SMP	YES
Consumption subsidies	Exogenous; endogenous*	Butter, SMP	YES
Production subsidies	Exogenous; endogenous*	Casein	YES
Commodity prices	Endogenous	10 products	
Commodity production	Endogenous	10 products	
Commodity consumption (subsidised and unsubsidised)	Endogenous	10 products	
Public intervention purchase	Endogenous	Butter, SMP	

**Table 8.2. cont.**

<b>Intra Trade (10 products, 9 regions)</b>			
Transportation costs	Exogenous		
Trade Flows	Endogenous		

\* Both consumption and production subsidies can be endogenously adjusted. In that case, we assume that the subsidised price of the good remains stable. For example, a one Euro decrease (increase) in the price of butter induces a one Euro decrease (increase) in the subsidy.

**Table 8.3. Variables and parameters relating to external trade**

<b>EU-ROW Trade (10 products)</b>	<b>Status of the variable</b>	<b>Comments</b>	<b>Policy Instruments set by the modeller</b>
Transportation costs	Exogenous		
ROW supply function			
Supply elasticity	Parameter		
ROW demand functions			
Demand elasticities	Parameters		
UR subsidised export ceilings (quantities and expenditures)	Exogenous	4 categories of products: Butter, SMP, cheese, others	YES
UR import access commitments	Exogenous	Butter, SMP, cheese	YES
Export subsidies	Exogenous; endogenous*		YES
Import tariffs	Exogenous		YES
World prices	Endogenous		
EU Exports	Endogenous		
EU Imports	Endogenous		

\* Export subsidies can be endogenously adjusted. In that case, we assume that the subsidised price of the good remains stable. For example, a one Euro decrease (increase) in the price of butter induces a one Euro decrease (increase) in its export subsidy. They can also be adjusted in order to be consistent with a decrease in the intervention prices.

### 8.3. Policy simulations

#### 8.3.1. Definition of simulated scenarios

##### 8.3.1.1. The reference scenario

The reference scenario represents a hypothetical year-2000 situation defined as follows. The model is calibrated on 1995 data. Then supply and demand conditions are shifted:

- Milk supply: level of quotas defined for 2000; quota rents for 2000 estimated from quota market data and simulation works from the literature.
- EU demands: shifted from 1995 to 2000 according to annual trends in consumption (from European Commission work, CAP reports, etc.).
- No public intervention.
- World markets: average situation 1996-99.
- Uruguay Round commitments: subsidised exports and minimum and current access for imports.
- Production/consumption subsidies: values for the year 2000.
- Export subsidies: equal to the differences between EU and world prices (theoretical consistency).

#### *8.3.1.2. Policy reform scenarios*

Seven policy scenarios are defined. In order to simplify the presentation of these scenarios, an abbreviation is associated to each policy instrument. Then, a number, "0", "1" or "2" is associated to each abbreviation according to whether the corresponding policy instrument is, respectively, "unchanged", "changed" or "removed". Scenarios thus rely on the following alternatives for the various considered policy instruments:

- Milk quotas (Q): Berlin agreement i.e., +2.4% increase in average but country specific, with respect to the reference scenario (Q1); Removed (Q2); decreased by -2.4% in each EU region (Q-1).
- Direct payment, as defined in the Berlin agreement (DP): they are considered as fully decoupled; no direct payment (DP0), direct payment as decided in Berlin (DP1).
- Intervention prices: no stocks.
- Domestic subsidies (D): adjusted in order to maintain the subsidised price constant (D1) with respect to the reference scenario; removed (D2).
- Export commitments (UR): unchanged (UR0) with respect to Uruguay Round commitments; further 36% and 21% cuts in, respectively, the value and the volume of subsidised exports, with respect to the reference scenario.
- Export subsidies (E): unchanged (E0); adjusted on the basis of a -15% decrease in intervention prices with respect to the reference scenario (E1); cut by 50% (E1bis); removed (E2).
- Import access (I): unchanged (I0); doubled with respect to the reference scenario (I1).
- Import tariffs (IT): unchanged (IT0), further -36% cut with respect to the reference scenario (IT1).

Then, the seven policy scenarios are defined as follows:

- **S1: "Berlin" scenario** includes an increase in milk quotas (Q1), a direct payment to producers (DP1), a decrease in the export subsidies (E1) as well as in the domestic subsidies (D1) corresponding to a -15% decrease in intervention prices. UR export and import commitments remain unchanged (IT0, UR0 and I0) relative to the reference run.
- **S2: "Berlin WTO" scenario** is defined as the "Berlin" scenario except that further restrictions on subsidised exports commitments (UR1) and further increase in import access commitments (I1) are assumed.
- **S3: "Quota off" scenario** is defined as the "Berlin" scenario except that we assume that milk quotas are removed (Q2).
- **S4: "Quota off WTO" scenario** is defined as the "Berlin WTO" scenario except that we assume that milk quotas are removed (Q2).
- **S5: "Quota off Liberalisation" scenario** assume quota removal (Q2), removal of export and domestic subsidies (E2 and D2), doubled import access (I1) unchanged import tariffs (IT0), direct payment to producers at the level decided in the Berlin agreement (DP1).
- **S6: "Cut Subsidies" scenario** involves domestic and export subsidy removal (D2 and E2) and a direct payment to producers at the level decided in the Berlin agreement (DP1). While no change in quota levels (Q0) neither in UR import commitments (I0 and IT0) are assumed.
- **S7: "Cut Subsidies and Decreased Quotas" scenario** is defined as the "Cut Subsidies" scenario except that milk quotas are decreased by -2.4% (Q-1) and there is no direct payment to producers (DP0).

As previously explained, we assume that public intervention is not allowed. In other words, we let SMP and butter prices be adjusted as required by market equilibrium conditions without any public purchases.

### **8.3.2. Simulation results**

Tables 8.5 to 8.8 summarise the simulation results relating to the EU milk and dairy markets, obtained for the reference run and the 7 above described policy scenarios. Table 8.4, which reports for each dairy product the shares of subsidised uses as well as the levels of the corresponding consumption or export subsidies observed at the EU aggregate level observed in 1998, helps for understanding the simulation results.

Indeed, Table 8.4 shows that a substantial share of the EU use of butter, SMP and WMP strongly depends on subsidies. First, 2/3 of the EU WMP production is exported with large export refunds

(45% of the EU price). Second, around 40% of the EU SMP production is used for subsidised consumption (animal feeding) while 15% is exported. Corresponding subsidies represent between 35 to 40% of the EU price. Third, as for milk powders, butter use in the EU heavily depends on subsidies. On the contrary, only 6% of the EU cheese production (excluding processed cheese) is exported, the remaining being used for unsubsidised domestic consumption. Moreover, the corresponding value of export subsidies is relatively small (31% in average). In the same way, liquid milk (and fresh products) is mainly used for unsubsidised domestic consumption. These figures suggest that in policy reform simulations, the levels of production of butter, SMP and WMP will greatly depend on the assumptions made in terms of changes in the levels of subsidies while it will not be the case for the production of other dairy products.

**Table 8.4. Shares of subsidised uses and levels of corresponding subsidies in the EU for the different dairy products (1998)**

	Share of uses (%)			Subsidies (in % of EU price)	
	Unsubsidised consumption	Subsidised Consumption	Exports	Consumption	Export
Butter	63.3	26.9	9.6	32	57
SMP	42.1	42.4	15.5	35	41
WMP	36.9	0.0	63.1		45
Concentrated Milk	73.4	0.0	26.6		8
Processed cheese	77.1	0.0	22.9		10
Cheese*	93.6	0.0	6.4		31**
Fluid milk	100				

\* Except processed cheese; \*\* Depending on cheese types; source: ZMP (production)

**Table 8.5. Impact of policy reform scenarios on the EU production of milk and dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Milk</b>	113796	101.8	101.5	104.3	102.9	99.4	99.5	97.3
<b>Fluid Milk</b>	31039	100.7	101.2	101.5	101.6	101.5	101.3	100.9
<b>Butter</b>	1593	101.7	99.7	105.6	102.2	95.0	95.8	92.1
<b>SMP</b>	1065	100.5	88.2	101.3	90.3	83.9	87.5	81.4
<b>Fresh Products</b>	7676	100.4	100.4	100.6	100.6	100.7	100.5	100.3
<b>Whole Milk Powder</b>	1046	98.5	102.9	107.9	108.1	79.1	75.1	68.7
<b>Condensed Milk</b>	1341	106.0	107.1	109.3	109.7	110.6	108.5	105.4
<b>Casein</b>	105	112.6	134.3	137.1	144.2	116.8	113.2	106.6
<b>Soft blue Fresh Cheese</b>	3248	102.6	104.0	104.5	104.7	105.0	104.4	103.3
<b>Hard Semi Hard Cheese</b>	3179	103.4	102.4	106.3	104.1	104.4	105.3	103.2
<b>Processed Cheese</b>	520	103.5	103.9	105.6	104.8	106.3	106.2	104.7

Units: 1000 tonnes for the reference scenario, indexes (base 100 for the reference) for other scenarios.

**Table 8.6. Impact of policy reform scenarios on the EU prices of milk and dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Milk</b>	0.273	86.5	79.6	74.7	73.9	71.9	76.7	83.0
<b>Fluid Milk</b>	0.473	94.4	91.1	88.8	88.5	88.9	90.4	93.1
<b>Butter</b>	2.875	88.3	85.7	85.4	83.9	69.3	76.0	81.1
<b>SMP</b>	1.882	88.7	77.5	76.3	73.0	75.6	77.1	80.1
<b>Fresh Products</b>	1.927	97.0	95.8	95.1	94.9	93.6	94.6	96.0
<b>Whole Milk Powder</b>	2.501	88.0	83.2	81.3	80.5	68.4	69.9	72.4
<b>Condensed Milk</b>	1.556	96.3	94.0	92.8	92.6	92.1	93.2	95.0
<b>Casein</b>	7.979	93.8	87.6	86.9	85.1	86.5	87.4	89.1
<b>Soft blue Fresh Cheese</b>	2.906	95.4	92.9	92.0	91.6	91.1	92.1	94.1
<b>Hard Semi Hard Cheese</b>	3.791	93.0	88.7	87.4	86.4	86.1	88.6	91.5
<b>Processed Cheese</b>	4.984	96.3	94.6	94.0	93.7	92.0	93.3	95.0

Units: Euros/kg for the reference scenario, indexes (base 100 for the reference) for other scenarios.

**Table 8.7. Impact of policy reform scenarios on the EU consumption of dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Fluid Milk</b>	30786	100.6	101.0	101.3	101.3	101.3	101.1	100.8
<b>Butter</b>	1470	104.2	106.2	106.5	107.6	118.8	113.7	109.8
<b>SMP</b>	955	100.6	101.6	101.4	101.5	98.0	96.8	94.2
<b>Fresh Products</b>	7602	100.3	100.5	100.6	100.6	100.7	100.6	100.5
<b>Whole Milk Powder</b>	501	103.8	105.4	106.0	106.2	110.0	109.5	108.7
<b>Condensed Milk</b>	1535	102.8	104.5	105.5	105.7	106.0	105.1	103.8
<b>Casein</b>	136	99.9	107.0	108.1	110.7	108.7	107.4	104.9
<b>Soft blue Fresh Cheese</b>	3196	102.5	103.8	104.3	104.5	104.8	104.2	103.1
<b>Hard Semi Hard Cheese</b>	2947	103.7	105.9	106.6	107.1	107.3	106.0	104.4
<b>Processed Cheese</b>	430	102.0	102.9	103.2	103.4	104.3	103.6	102.7

Units: 1000 tonnes for the reference scenario, indexes (base 100 for the reference) for other scenarios.

**Table 8.8. Impact of policy reform scenarios on milk component shadow prices**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Fat</b>	3.233	87.4	85.3	84.3	83.4	68.9	75.2	81.1
<b>Protein</b>	4.957	87.7	77.8	70.4	69.7	78.0	81.2	86.9

Units: Euros/kg for the reference scenario, indexes (base 100 for the reference) for other scenarios.

In scenarios S1 and S2, quotas are increased and export refunds are decreased. This leads to a decrease in the price of raw milk by -15 to -20%. Due to processing and distribution costs, which remain roughly constant, the decreases in the prices of processed products are proportionally lower (cf. Table 8.6). As in some countries, quotas are no longer binding, the EU total milk production increases less than the quota change (1.5 to 1.8% vs 2.4%). Except for casein, the productions of final dairy products show small increases (cf. Table 8.5).

In scenarios S3 and S4, the increase in production following the quota removal causes a large decrease in the raw milk price (-24 to -25%). Note that because aggregate demand is rather inelastic, the increase in production remains small (3 to 4%), but induces a large decrease in the price of milk. Increases in production of the different processed dairy products is rather equally distributed (except for casein). As in scenario S2, the EU SMP production decreases in S4 because Uruguay Round commitments in terms of subsidised exports are binding and constraint EU exports (while this is not the case for butter).

Scenarios S5 and S6 differ in their respective assumptions on the import side and on quotas. The levels of EU production of milk and dairy products are nevertheless very similar in both scenarios. In

scenario S6, quotas remain in force but consumption and export subsidies are removed and market access is doubled. Hence, quotas are no longer binding and the EU milk production slightly decreases with respect to the reference run (-0.5%, cf. Table 8.5). In scenario S5, quotas are removed and one expects the EU milk production to increase. However, this scenario also assumes subsidy removal and thus induces a large decrease in the EU price of milk (nearly 30%, cf. Table 8.6). This price decrease finally induce a slight decrease in milk production (-0.6%). The observed difference in milk price change between scenarios S5 and S6 is essentially due to the impact of increasing imports in scenario S5. As export subsidies are cut, the EU productions and prices of WMP, SMP and, in a lower extent, of butter decrease substantially. On the contrary, productions of other dairy products increase in response to the increase in demand generated by the decrease in corresponding prices.

Finally in scenario S7, as compared with scenario S6, the price of raw milk decreases less (-17% instead of -23%) in response to the decrease in production. Now the quotas are binding in all countries and the decrease in the quota levels implies an increase in the quota rent. As compared to scenario S6, prices of dairy products are higher. Conversely, their production levels are lower, especially for SMP, butter and WMP.

Tables 8.9 and 8.10 reports the simulation results relating to EU dairy trade, obtained for the reference and the 7 considered policy reform scenarios.

**Table 8.9. Impact of policy reform scenarios on EU exports of dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Fluid Milk</b>	266	111.5	119.1	128.7	129.0	127.9	121.3	117.3
<b>Butter</b>	269	86.6	96.4	97.9	103.5	0.0	0.0	0.0
<b>SMP</b>	273	100.0	73.4	100.0	81.8	69.1	62.3	47.6
<b>Fresh Products</b>	74	106.7	94.3	100.8	97.5	99.7	92.2	86.5
<b>Whole Milk Powder</b>	581	93.8	100.3	108.7	108.7	53.0	46.4	35.6
<b>Condensed Milk</b>	304	106.0	98.4	101.4	101.9	103.1	100.3	96.2
<b>Casein</b>	43	119.3	138.1	140.4	145.9	108.5	105.6	100.4
<b>Soft blue Fresh Cheese</b>	53	109.9	115.5	118.3	119.1	120.3	117.3	112.8
<b>Hard Semi Hard Cheese</b>	321	100.0	98.1	101.4	103.7	104.6	98.2	90.9
<b>Processed Cheese</b>	95	110.1	114.7	116.6	117.5	121.8	118.0	113.4

Units: 1000 tonnes for the reference scenario, indexes (base 100 for the reference) for other scenarios.

**Table 8.10. Impact of policy reform scenarios on EU imports of dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Fluid Milk</b>	12	92.8	88.1	86.4	86.4	88.9	89.6	94.7
<b>Butter</b>	87	100.0	200.0	100.0	200.0	200.0	100.0	100.0
<b>SMP</b>	68	100.0	200.0	100.0	200.0	200.0	100.0	100.0
<b>Fresh Products</b>	2	96.8	95.8	95.2	95.2	93.9	94.6	96.1
<b>Whole Milk Powder</b>	6	73.7	63.0	58.8	57.0	32.1	35.4	40.8
<b>Condensed Milk</b>	485	96.1	93.8	92.5	92.2	91.7	93.0	94.7
<b>Casein</b>	74	92.9	86.1	85.2	83.2	96.9	97.9	99.8
<b>Soft blue Fresh Cheese</b>	2	104.3	237.9	107.7	239.1	239.2	106.6	104.9
<b>Hard Semi Hard Cheese</b>	89	99.8	201.0	99.6	200.9	201.0	99.7	99.8
<b>Processed Cheese</b>	8	101.4	180.7	103.2	181.3	180.1	101.8	101.3

Units: 1000 tonnes for the reference scenario, indexes (base 100 for the reference) for other scenarios.

In scenarios S2 and S4, Uruguay Round commitments on subsidised exports are more restrictive than in other scenarios. Then, the EU SMP exports decrease to the corresponding commitment ceiling level (cf. Table 8.9). The decrease in subsidised exports of cheese is compensated by an increase in unsubsidised exports in response to the decrease in EU prices. The decrease in the subsidised exports of "other products" causes a decrease in the exports of fresh products while WMP exports remain roughly stable

When export subsidies are cut (scenarios S5, S6 and S7), butter is no longer exported by the EU while exports of SMP as well as WMP are significantly reduced (cf. Table 8.9).

Tables 8.11 and 8.12 report the simulation results in terms of welfare in the EU, obtained for the reference and the 7 considered policy reform scenarios.

**Table 8.11. Impact of policy reform scenarios on EU producer, taxpayer and consumer surplus and welfare (millions Euros, Scenarios S1 to S7: absolute variation relative to the reference scenario)**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Producers</b>	18127	-1234	-3421	-4905	-5172	-5820	-4351	-5379
<b>Taxpayers</b>	-1731	-2080	-1600	-1823	-1579	-813	-989	1911
<b>Consumer</b>		3280	5089	5860	6213	7258	6050	4490
<b>EU welfare (1)*</b>		246	478	-46	212	1069	988	1073
<b>EU welfare (2)**</b>		-170	158	-411	-104	906	790	1455

\* Change in welfare assuming that opportunity costs of public funds are zero. Hence direct payments do not induce any welfare cost.

\*\* Change in welfare assuming that opportunity costs of public funds are equal to 0.2. Then direct payments induce a welfare cost of 0.2 Euro per Euro of direct payment.

**Table 8.12. Impact of policy reform scenarios on EU taxpayer costs (millions Euros)**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Taxpayer costs</b>	1731	3812	3332	3554	3310	2544	2721	-180
<b>Tariff</b>	-247	-241	-412	-235	-410	-356	-179	-180
<b>Export subsidies</b>	1460	935	767	830	801	0	0	0
<b>Domestic subsidies</b>	519	218	77	59	19	0	0	0
<b>Direct payments</b>	0	2900	2900	2900	2900	2900	2900	0

All scenarios lead to dramatic changes in the distribution of surpluses in the EU. Producer surplus decreases (from -1.2 billion Euros in scenario S1 to up to -5.8 billion Euros in scenario S5) and consumer surplus increases (from 3.3 billion Euros in scenario S1 to up to 7.3 billion Euros in scenario S5, cf. Table 8.11) in all scenarios. In all scenarios, but scenario S7, taxpayers experience surplus losses but the magnitudes of these losses vary significantly across scenarios. In particular, Table 8.11 suggests that taxpayers' losses are sensitive to the adopted assumption regarding consumption and export subsidies. Indeed scenarios S5 and S6, which assume that all these subsidies are removed both lead to the lowest loss for EU taxpayers (around -0.9 billion Euros as compared -1.6 to 2.1 in other scenarios).

Except for scenario S3, all scenarios are welfare increasing for the EU, scenario S7 being the most welfare enhancing. Comparing scenarios S1, S2, S3, S4 on the one hand and scenarios S5, S6, S7 on the other hand, one sees that the removal of consumption and export subsidies is particularly welfare increasing for the EU. This is essentially due to the large country effect resulting from the removal of export subsidies. An "artificial" increase in EU exports (i.e., generated by an export subsidy) causes a decrease in world prices because EU is a major exporter on the world dairy markets. Conversely a reduction in EU exports increases EU welfare because world market prices increase. Scenario S3 illustrates the negative welfare impact of an increase in production while keeping constant price distortions. Scenario S7 is the most appealing in terms of welfare essentially because, as compared to scenario S6, the milk quotas are still in force and contribute to limit the decrease in the price of milk. As a result, taxpayers costs decrease (cf. table 8.12) so that taxpayers benefit from a surplus gain in this scenario. A substantial share of the policy cost is shifted on consumers but, as the aggregate demand for milk is rather inelastic, the extra surplus loss for consumers (as compared to scenario S6) is limited. In such a situation, the production quota instrument appears as a rather "efficient" way to transfer surplus from consumers to producers.

Finally, Table 8.12 indicates that direct payments to producers account for the largest share of EU taxpayers costs. Note that in the first definition of welfare, a transfer from taxpayer to producer is

neutral since there is no opportunity cost of public funds and direct payments are assumed to be fully decoupled.

**Table 8.13. Impact of policy reform scenarios on the world prices of dairy products**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>Fluid Milk</b>	0.583	95.3	92.2	88.3	88.1	88.6	91.3	92.9
<b>Butter</b>	1.267	107.9	102.1	101.2	98.0	158.5	158.5	158.5
<b>SMP</b>	1.379	100.0	107.5	100.0	105.1	108.7	110.6	114.7
<b>Fresh Products</b>	1.897	98.3	101.4	99.8	100.6	100.1	102.0	103.4
<b>Whole Milk Powder</b>	1.512	102.3	99.9	96.7	96.7	117.6	120.1	124.1
<b>Condensed Milk</b>	1.525	97.4	100.7	99.4	99.2	98.7	99.9	101.6
<b>Casein</b>	7.190	93.1	86.3	85.5	83.5	97.0	98.0	99.8
<b>Soft blue Fresh Cheese</b>	2.989	95.8	93.4	92.2	91.8	91.3	92.6	94.5
<b>Hard Semi Hard Cheese</b>	3.413	100.0	100.9	99.4	98.3	97.9	100.8	104.1
<b>Processed Cheese</b>	5.092	96.4	94.7	94.1	93.7	92.2	93.5	95.2

Units: Euros/kg for the reference scenario, indexes (base 100 for the reference) for other scenarios.

Changes in the EU dairy policy affect the world prices of "basic" dairy commodities (butter, SMP and WMP). This point is illustrated by the comparing, in Table 8.13, of the world price changes induced by scenarios S1 to S4 on the one hand and by scenario S5 to S7 on the other hand.

Tables 8.14 and 8.15 summarise the results in terms of milk production and price for the various considered EU regions, obtained for the reference and the 7 policy reform scenarios.

**Table 8.14. Impact of policy reform scenarios on milk production in the various considered EU regions**

	Reference	S1	S2	S3	S4	S5	S6	S7
<b>France</b>	23040	101.6	101.6	103.9	101.7	95.7	100.0	97.5
<b>Belgium &amp; Luxembourg</b>	3267	101.6	101.6	100.4	99.5	95.6	99.1	97.5
<b>Netherlands</b>	10765	101.5	101.5	112.2	111.0	108.0	100.0	97.5
<b>Germany &amp; Austria</b>	29442	101.6	101.6	102.0	100.7	97.1	100.0	97.5
<b>Italy &amp; Greece</b>	10641	106.3	105.1	102.3	100.3	98.4	100.0	97.7
<b>United Kingdom &amp; Ireland</b>	19290	102.0	102.0	108.3	107.4	105.1	100.0	97.6
<b>Denmark</b>	4465	101.5	101.5	115.8	114.5	109.3	100.0	97.6
<b>Spain &amp; Portugal</b>	7255	96.6	93.5	92.3	91.7	90.3	91.9	94.3
<b>Sweden &amp; Finland</b>	5629	101.5	101.5	101.7	100.9	99.1	100.0	97.6

Units: 1000 tonnes for the reference scenario, indexes (base 100 for the reference) for other scenarios.

**Table 8.15. Impact of policy reform scenarios on the price of milk in the various EU regions**

	Reference	S1	S2	S3	S4	S5	S6	S7
France	0.261	85.7	78.2	75.4	74.3	71.4	73.8	79.8
Belgium & Luxembourg	0.279	85.5	78.4	74.9	74.3	71.4	74.0	79.8
Netherlands	0.297	86.3	79.1	69.1	68.3	66.4	76.6	83.1
Germany & Austria	0.270	85.8	78.3	76.0	75.0	72.3	74.7	81.2
Italy & Greece	0.288	87.8	81.4	79.9	78.8	77.8	81.3	86.4
United Kingdom & Ireland	0.270	85.6	78.3	68.3	67.7	66.2	75.9	83.8
Denmark	0.299	86.5	79.9	68.0	67.4	65.3	75.5	81.6
Spain & Portugal	0.220	92.6	90.6	89.8	89.5	88.5	89.6	91.1
Sweden & Finland	0.320	87.4	81.2	79.0	78.6	77.6	80.3	88.1

Units: Euros/kg for the reference scenario, indexes (base 100 for the reference) for other scenarios.

For a given scenario, changes in the price of raw milk in the various EU regions are relatively homogenous as long as quotas and subsidies are maintained. They are slightly more differentiated within scenarios assuming the removal of one or both these types of instruments. In those cases, observed differences mainly reflect the initial levels of quotas rents characterising each region: the less competitive regions register lower decrease in the price of milk than the one experienced by the most competitive regions. The case of Spain and Portugal is specific because the milk quotas are not binding for these countries in the reference scenario. Thus, in all scenarios, the decrease in the price of milk is lower in this region compared to the other EU regions.

When milk quotas are removed the change in milk production is region specific. For example, in scenario S4, some regions experience increases in their production level while other ones register decreases. Increasing production in some regions reflects their capacity (due to their initial quota rent level) to expand production despite the accompanying price decrease. When quotas are active, changes in production are more uniformly distributed among regions.

#### 8.4. Conclusion and policy recommendations

The analysis performed with this model is a comparative static analysis which means that the results provide the impact of policy scenarios *ceteris paribus*. It is also implicit that the new equilibrium is reached instantaneously. Therefore, results indicate in which direction EU milk and dairy markets adjust to policy changes, but no information is given on the path of adjustment between the initial and the equilibrium.

The main conclusions and policy recommendations that can be drawn from our analysis may be synthesised as follows:

- i) Due to both the inelasticity of EU demand and the Uruguay Round constraints on exports, an 1% increase in EU milk production induces a -4% decrease in milk price.
- ii) EU cheese, fresh products, liquid milk and condensed milk production increase in all considered policy reform scenarios. This is due to the increase in the domestic consumption of these products that follows the decrease in their prices. Conversely, the impacts of policy reform scenarios on EU butter, SMP and whole milk powder production depend closely on the level of subsidies (domestic and/or export subsidies). The production of these products decreases when subsidies are significantly reduced.
- iii) The decrease in subsidised exports has a positive impact on world prices.
- iv) Larger increases in welfare occur when the EU cuts its export subsidies and domestic subsidies. This conclusion is reinforced when the opportunity costs of public funds are taken into account.
- v) Removing quotas without changing internal price support leads to an important decrease in EU welfare.
- vi) Under full liberalisation, the EU milk production does not increase. It roughly remains constant.
- vii) Because aggregate demand for milk is rather inelastic, the quota instrument is an efficient instrument for redistributive purpose. When opportunity cost are taken into account, they appear to be more efficient than direct payments in order to redistribute surplus to producers. In a long term perspective, keeping EU milk price at high level (relatively to milk prices in other countries) could lead some firms to locate their productions in other countries (only for products which can be easily traded).

## APPENDIX 1.

### description of the Spatial Equilibrium model with Component Allocation

In order to analyse the impact of policy reforms in the EU dairy sector, a spatial equilibrium model for a vertical sector has been developed. The model involves  $J$  regions and two sets of commodities: primary commodities and processed commodities. The primary commodities are not consumer goods, they are used exclusively as inputs in the production of processed commodities. Each region is a potential producer of the primary commodities, and a potential producer as well as a potential consumer of the processed commodities. Also, each region can trade both primary and processed commodities with any other region. The corresponding competitive spatial market equilibrium can be analysed by developing a market equilibrium model of resource allocation and trade over the  $J$  regions.

Let  $N$  be the number of primary commodities.  $w_{in}$  denotes the quantity produced of the  $n^{\text{th}}$  primary commodity in region  $i$ , and  $x_{in}$  is the derived demand for the  $n^{\text{th}}$  primary commodity used as an input in the production of the processed commodities in region  $i$ , ( $n = 1, \dots, N, i = 1, \dots, J$ ). Let  $K$  be the number of processed commodities.  $y_{ik}$  denotes the production level of the  $k^{\text{th}}$  processed commodity in region  $i$ , and  $z_{ik}$  is the consumption level of the  $k^{\text{th}}$  commodity in region  $i$ , ( $k = 1, \dots, K, i = 1, \dots, J$ ).

The allocation decisions are illustrated in Figure 8.1. The production of the processed commodities ( $y$ ) is influenced by the production technology transforming  $x$  into  $y$ , and by the interregional trade in the primary commodities. Consumption of the processed commodities  $z$  is influenced by corresponding production  $y$  and by the interregional trade in the processed commodities. Denote by  $T_{ijn} \geq 0$  the export of the  $n^{\text{th}}$  primary commodity from region  $i$  to region  $j$ . Similarly, denote by  $t_{ijk} \geq 0$  the export of the  $k^{\text{th}}$  processed commodity from region  $i$  to region  $j$ . Using this notation,  $T_{iin} \geq 0$  is the quantity of the  $n^{\text{th}}$  primary commodity that is both produced and used in the production of the processed commodities within the  $i^{\text{th}}$  region (i.e., not exported to other regions). And  $t_{iik} \geq 0$  is the quantity of the  $k^{\text{th}}$  processed commodity that is both produced and consumed in the  $i^{\text{th}}$  region. See Figure 8.1.

The production of the processed commodities  $y$  involves basic components that are an integral part of the primary commodities and that are "rearranged" and allocated among processed commodities. Assume that the  $N$  primary commodities involve  $S$  components. In region  $i$ , let  $a_{ins}$  denote the quantity of the  $s^{\text{th}}$  component per unit of derived demand of the  $n^{\text{th}}$  primary commodity  $x_{in}$ . And let  $b_{iks}$  denote the quantity of the  $s^{\text{th}}$  component per unit of production of the  $k^{\text{th}}$  processed commodity. Under a Leontief technology, the transformation of the primary inputs  $x$  into the processed inputs  $y$  in region  $i$  must satisfy:

$$\sum_{k=1}^K y_{ik} b_{iks} \leq \sum_{n=1}^N x_{in} a_{ins} \quad i = 1, \dots, J; s = 1, \dots, S \quad (1)$$

Equation (1) ensures that the allocation of component  $s$  in region  $i$  is balanced. It corresponds to a linear Lancasterian model where each commodity exhibits fixed proportions, but where the components are perfect substitutes in their allocation among commodities (see Lancaster, 1971). Besides the processing of the  $S$  components, the production of processed commodities ( $y_{i1}, \dots, y_{iK}$ ) from ( $x_{i1}, \dots, x_{iN}$ ) in region  $i$  also involves labour and capital inputs, which are provided at cost  $G_i$ . Denote the associated cost function by  $G_i(y_{i1}, \dots, y_{iK}, x_{i1}, \dots, x_{iN})$ , where  $\partial G_i / \partial y_{ik} > 0$  ( $k = 1, \dots, K$ ), and  $\partial G_i / \partial x_{in} < 0$  ( $n = 1, \dots, N$ ), for all  $i = 1, \dots, J$ .

The trade flow constraints across regions are:

$$w_{in} \geq \sum_{j=1}^J T_{ijn} \quad (2a)$$

$$\sum_{j=1}^J T_{jin} \geq x_{in} \quad (2b)$$

$$y_{ik} \geq \sum_{j=1}^J t_{ijk} \quad (2c)$$

$$\sum_{j=1}^J t_{jik} \geq z_{ik} \quad (2d)$$

In any region, these equations guarantee that exports plus domestic use cannot be larger than domestic production, and that domestic consumption cannot exceed domestic production plus imports. This holds for primary commodities (equations (2a) and (2b)) as well as for processed commodities (equations (2c) and (2d)).

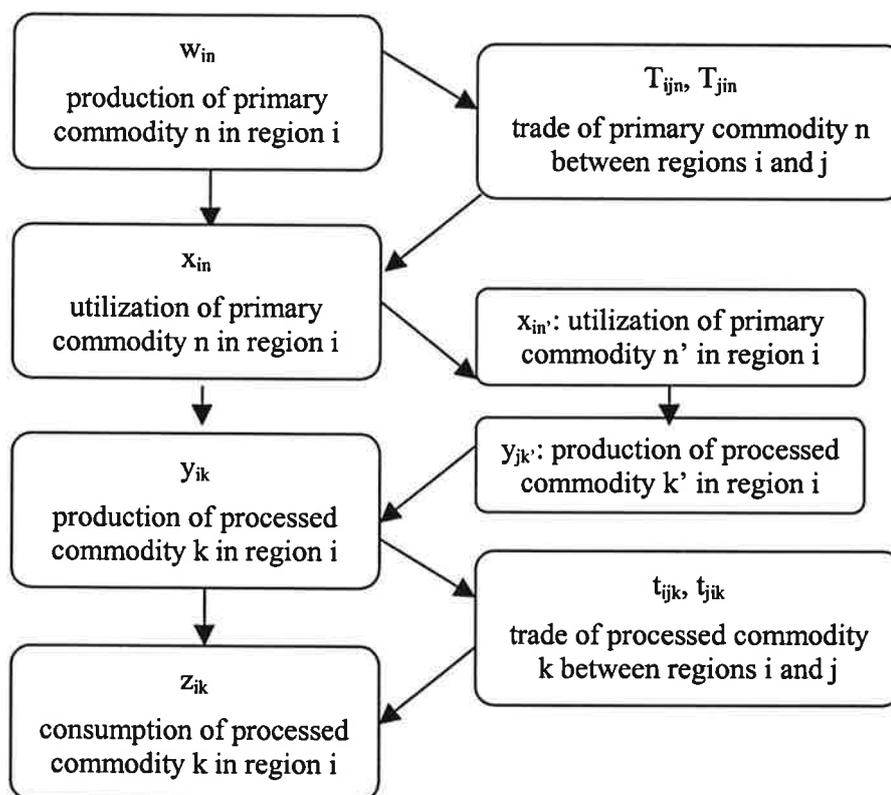
Denote by  $D_i(z_{i1}, \dots, z_{iK})$  the total benefit of consumers in region  $i$ , and by  $S_i(w_{i1}, \dots, w_{iN})$  the production cost in region  $i$ . Assume that  $D_i(z_{i1}, \dots, z_{iK})$  is a convex function and that  $S_i(w_{i1}, \dots, w_{iN})$  is a concave function. Under competitive markets, let the price of the  $k^{\text{th}}$  processed commodity in the  $i^{\text{th}}$  region be  $p_{ik}^d = \partial D_i / \partial z_{ik}$ , stating that price is equal to consumers' marginal benefit. Similarly, let the price of the  $n^{\text{th}}$  primary commodity in the  $i^{\text{th}}$  region be  $p_{in}^s = \partial S_i / \partial w_{in}$ , stating that price is equal to marginal cost. Also, let  $C_{ijn} \geq 0$  be the unit cost of transporting the  $n^{\text{th}}$  primary commodity from region  $i$  to region  $j$ , with  $C_{iin} = 0$ , and  $c_{ijk} \geq 0$  be the unit cost of transporting the  $k^{\text{th}}$  processed commodity from region  $i$  to region  $j$ , with  $c_{iik} = 0$ .

As a basis for representing resource allocation, consider the following optimisation problem:

$$\begin{aligned} & \text{Max}_{w,x,y,z,T,t} \{ \sum_{i=1}^J [D_i(z_{i1}, \dots, z_{iK}) - S_i(w_{i1}, \dots, w_{iN})] - \sum_{i=1}^J G_i(y_{i1}, \dots, y_{iK}, x_{i1}, \dots, x_{iN}) \\ & - \sum_{i=1}^J \sum_{j=1}^J \sum_{n=1}^N T_{ijn} C_{ijn} - \sum_{i=1}^J \sum_{j=1}^J \sum_{k=1}^K t_{ijk} c_{ijk} \} \\ & \text{subject to: equations (1) and (2a)-(2d), } w \geq 0, x \geq 0, y \geq 0, z \geq 0, T \geq 0, t \geq 0 \end{aligned} \quad (3)$$

The objective function in (3) can be interpreted as a quasi-welfare function. It is equal to  $\sum_{i=1}^J [D_i - S_i]$ , the sum of producer and consumer surpluses across all regions; minus  $\sum_{i=1}^J G_i$ , the total cost of labour and capital in the processing sector; minus  $[\sum_{i=1}^J \sum_{j=1}^J \sum_{n=1}^N T_{ijn} C_{ijn} + \sum_{i=1}^J \sum_{j=1}^J \sum_{k=1}^K t_{ijk} c_{ijk}]$ , the total cost of transportation. The solution to (3) can be shown to generate a competitive resource allocation (see Chavas, Cox and Jesse, 1998). The Lagrange multipliers associated with (2a)-(2d) represent market prices, while the Lagrange multipliers associated with (1) give the shadow prices of the components of the primary commodities. By incorporating components allocation both across commodities and regions, this competitive market equilibrium framework extends the interregional competitive model proposed by Samuelson (1952) and Takayama and Judge (1971). The paper of Bouamra-Mechemache et al. (2001) shows how this framework can be modified to incorporate the EU dairy policy instruments so as to represent distorted competitive market equilibrium under alternative policy scenarios relevant to the European dairy industry.

**Figure 8.1. The allocation process of primary and processed commodities**



## APPENDIX 2.

### Assumptions on supply and demand elasticities and on initial quota rents

**Table 8.16. Supply elasticities for milk in each European Union region**

	Supply elasticity
<b>France</b>	1.50
<b>Belgium &amp; Luxembourg</b>	1.00
<b>Netherlands</b>	1.00
<b>Germany &amp; Austria</b>	1.00
<b>Italy &amp; Greece</b>	1.50
<b>United Kingdom &amp; Ireland</b>	1.00
<b>Denmark</b>	1.50
<b>Spain &amp; Portugal</b>	1.50
<b>Sweden &amp; Finland</b>	1.50

**Table 8.17. Demand elasticities for each dairy product**

	Elasticity of demand
<b>Fluid Milk</b>	-0.125
<b>Butter</b>	
Unsubsidised demand	-0.4
Subsidised demand	-1.0
<b>SMP</b>	
Unsubsidised demand	-0.2
Subsidised demand	-1.0
<b>Fresh Products</b>	-0.125
<b>Whole Milk Powder</b>	-0.4
<b>Condensed Milk</b>	-0.8
<b>Casein*</b>	-1.0
<b>Soft blue Fresh Cheese</b>	-0.6
<b>Hard Semi Hard Cheese</b>	-0.6
<b>Processed Cheese</b>	-0.6

\* The production of casein is subsidised.

**Table 8.18. Unit quota rent in proportion of the milk price for each European Union region**

	<b>Unit quota rent</b>
<b>France</b>	35 %
<b>Belgium &amp; Luxembourg</b>	35 %
<b>Netherlands</b>	45 %
<b>Germany &amp; Austria</b>	35 %
<b>Italy &amp; Greece</b>	30 %
<b>United Kingdom &amp; Ireland</b>	45 %
<b>Denmark</b>	45 %
<b>Spain &amp; Portugal</b>	30 %
<b>Sweden &amp; Finland</b>	30 %



## **9 - ECONOMETRIC MODELS OF BEEF PRODUCING SECTORS IN MAIN EU MEMBER STATES**

### **Agenda 2000 and Beyond: Impact of reforms of the Common Market Organisation for beef**

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#### **9.1. Introduction**

The objective of this part of the project (i.e., subtask 2.3) was to develop a tool for simulating policy reform in the beef and veal sectors of the European Union. In order to provide an assessment of the impact of such policy reforms, at the national level and at the European level, sectoral econometric models have been developed. Changes in these beef and veal sectors are induced by the market conditions, and by policies. These policies may apply directly on these sectors, or they may affect related sectors. A fair representation of the beef and veal sectors must include these main determinants, and simultaneously the dynamic interactions among categories of animals, that is the demographic structure of the cattle and the associated biological constraints.

National models are developed for the main European beef and veal producers, i.e., France, Germany, United-Kingdom and Italy. These models are founded on a generic approach which aims to a good coverage of relevant variables and which specifies stock and flow variables with an explicit account for biological limits.

The objective is to account for the demographic structure of bovine production and for the impacts of economic variables (mainly prices) and agricultural policy variables (intervention price, headage premiums, milk quotas) on production. In other words, beef supply steadily depends on the bovine demographic characteristics: one of the concerns is here to take into account how economic or policy changes affect this (dynamic) link. The approach can be summarised as an inventory approach to model the livestock sector, which accounts for behavioural relationships to finally determine meat supply and trade. The model is made of a set of behavioural and biological relationships.

This approach requires a disaggregation of the livestock into categories of animals (calves for slaughtering, calves for breeding, adult male/female animals over 1 year, over 2 years, etc.) and a disaggregation of the net production (slaughterings of calves, bulls, steers, heifers, cows).

For each national model, parameters which link the variables of interest (calf crop, livestock addition, slaughtering rate, etc.) are assumed to be dependent on economic or policy variables (which will be the control variables of the model during the simulation step). But these parameters must also enforce biological constraints, which first implies to build a dynamic set of relationships between these variables. In that prospect, a particular attention is paid to the specification of the various variable rates. Most of them are specified as logistic functions. All the parameters of the model (except the biological upper limits which are fixed according to empirical observations and to common knowledge) are estimated using econometric techniques applied to time series data.

Models can be used to simulate a baseline scenario (including the "Agenda 2000" reform measures) and scenarios of decrease in the number and/or the level of premiums.

More generally, the dynamic characteristics of each model allows for computing dynamic elasticities of main endogenous variables with respect to control variables, such as policy variables. An illustration may be completed through the assessment of the effect of the number of beef premiums granted on net production.

In the following section, a brief presentation of the methodology used and the data set built is given. In section 3, the main quantitative results, among the main countries which have been modelled, are presented. Section 4 reports and discusses simulation results. Finally, section 5 concludes.

## **9.2. National models of beef and veal sectors: Structure and main characteristics**

For each main producing EU Member State (France, Germany, United-Kingdom, Italy) a complete model of the bovine sector is specified and estimated. Each national model simultaneously accounts for the demographic structure of bovine production and for the impacts of economic variables (mainly prices) and agricultural policy variables (intervention price, headage premiums, milk quotas) on production. The whole system is perfectly balanced over time, that is, the herd of one category of animals at the beginning of one period is necessarily equal to the sum of all possible utilisations during the period (slaughtering, net export, or herd replacement). This explicit intertemporal balance is at the core of the model functioning.<sup>134</sup>

Three subsets of relationships are defined for calves, female animals aged one year and over, and male animals aged one year and over. For each category, the herd at the beginning of one period is intended to be slaughtered, bred, or (net) exported during the period. These arbitrations apply to sub-categories

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<sup>134</sup> This is not always the case in models of animal markets. See, for example, Lianos and Katrinidis (1993) where the link between inventories and slaughterings do not insure the dynamic balance between supply and utilisations.

such as heifers, suckler cows and dairy cows for female animals, and bulls and steers for male animals. For each of these sub-categories, net production is determined at each period with respect to biological possibilities, which leads to the total net production.

The complete structure of the model is provided in appendix 1.

### 9.2.1. Demographic structure: An illustration

As an illustration, calves born during year  $t$  ( $BICA_t$ ) are a proportion  $cc_t$  of the female herd at the end of the year  $t-1$ , ( $FEHE_{t-1}$ ) where  $cc_t$  is the calf crop:  $BICA_t = cc_t \cdot FEHE_{t-1}$

These born calves are then allocated into calves for slaughtering, calves for breeding and net exports of lives calves (the latter can be derived from the former). Thus:

$CASL_t = csl_t \cdot BICA_t$  where  $CASL_t$  are calves for slaughtering and  $SLCA_t = slr_t \cdot CASL_t$  where  $SLCA_t$  are the slaughterings of calves (net production of veal is derived through the average slaughter weight).

$CABR_t = cbr_t \cdot BICA_t$  where  $CABR_t$  is the herd of calves for breeding, which itself is allocated into males and females, through the relationships  $MCAH_t = mal_t \cdot CABR_t$  and  $FCAH_t = (1 - mal_t) \cdot CABR_t$ , where  $MCAH_t$  and  $FCAH_t$  are respectively the herds of male and female calves for breeding.

These herds determine the herds of adult male and female animals the year after, and consequently slaughtering of each kind of animal through similar arbitration rates. For example, the herd of adult males is defined as:

$MAHE_t = \gamma_t \cdot MCAH_{t-1} + mrr_t \cdot (MAHE_{t-1} - XLMA_t + MLMA_t)$  where  $XLMA_t$  and  $MLMA_t$  are exports and imports of live adult male animals, respectively.  $\gamma_t$  is the share of the male adult cattle which comes from the herd of calves for breeding and  $mrr_t$  is the rate of replacement of the male adult cattle. Slaughterings and net production can be easily derived, and allocated into bulls and steers.

A similar process is written for adult female animals, which leads to net productions of heifers and cows, and then to the total net production of beef.

### 9.2.2. Impacts of economic and policy variables

It is assumed that each arbitration is a function of economic and policy variables. Hence, all the various rates ( $cc_t$ ,  $csl_t$ ,  $slr_t$ ,  $cbr_t$ ,  $mal_t$ ,  $\gamma_t$ ,  $mrr_t$ , etc.) which link the different variables are specified as functions of economic and policy variables. To ensure that these rates do not exceed realistic limits which are imposed by biological constraints, they are modelled as logistic functions of explanatory variables (for a similar way to deal with biological limits, see Fabiosa and Qi, 1998). Such a specification allows for setting an upper limit to each of these rates.

For any variable rate  $y_t$ , the specification is:  $y_t = \frac{y^+}{1 + e^{-x_t\beta}} + \varepsilon_t$ , where:  $y^+$  is the upper limit chosen for  $y_t$ ,  $X_t$  is a vector of explanatory variables,  $\beta$  is a vector of parameters, and  $\varepsilon_t$  is an error term. The upper limit is fixed before estimation, and its value is determined according to empirical observations on the concerned rate over the sample, and according to common knowledge.

The effect on  $y_t$  of one variable of  $X_t$  is of the sign of the corresponding parameter of  $\beta$ . The elasticity of  $y_t$  with respect to a variable  $x_{it}$  of  $X_t$  (which is assumed to be affected by a parameter  $\beta_i$ ) is given by:  $\varepsilon_{y_t/x_{it}} = \beta_i x_{it} (1 - \frac{y_t}{y^+})$ . This elasticity can be computed for any sample point, or generally for the sample mean point. Note that this elasticity only measures the instantaneous effect of  $x_{it}$  on  $y_t$ , *ceteris paribus*. Actually, it does not take into account the simultaneous characteristic of the model: for example,  $x_{it}$  may appear as an explanatory variable in another relationship which explains a variable which explains  $y_t$  too. Moreover, this kind of direct or indirect effect may occur at time  $t$ , or between two consecutive periods. The previous elasticity only offers partial information, limited to the comparison among effects inside only one relationship. Therefore it is necessary to compute dynamic multipliers which take into account both direct and indirect effects of each exogenous variable on one endogenous variable. Due to the expression of the key rates which link these variables in terms of logistic functions, the complete model is highly nonlinear, and a linear approximation would be hardly tractable. Thus, these dynamic multipliers and the associated elasticities must be approximated through simulation methods.

Estimation of relationships where these variable rates appear finally lead to the slaughterings expressed in heads for each category of animals (calves, heifers, cows, bulls and steers). Relationships which define the average slaughter weights are then estimated in the same manner (the average slaughter weight for each kind of animal is modelled as a logistic function of explanatory variables, such as the lagged weight reflecting biological constraint, and the price of animal feedingstuffs). Finally, the net productions expressed in carcass weight equivalent are obtained as the product of slaughterings by the average slaughter weight.

Producer prices are endogenous in the model, and they are the only variables which are expressed in linear form. Prices for calves and for adult cattle are taken into consideration. The real producer price indexes are expressed as a function of the real intervention price and of the excess supply. For both categories, the excess supply is defined as the difference between net production and domestic consumption, which is assumed to be exogenous.

For the other relationships, the main explicative variables are these real price indexes and the agricultural policy variables, which are exogenous. These are essentially: the total amount of male premiums granted, differentiated whether it is the first or the second payment, and accordingly to bulls and steers, the total amount of suckler cow premiums granted, and the national milk quota level. Exogenous variables also include imports of live animals for calves, heifers, cows and steers.

This leads to a set of endogenous variables and equations, among which some are identities (see the list in Table 9.1, which corresponds to the French model).

**Table 9.1. The set of endogenous variables (example of the French beef model)**

Dependent variable		Identities
<i>Calves</i>		
$BICA_t$	Births of calves	
$CAHE_t$	Total herd of calves at the end of year $t$	€
$CASL_t$	Herd of calves for slaughtering	
$SLCA_t$	Number of calves slaughtered	
$CABR_t$	Herd of calves for breeding	
$MCAH_t$	Herd of male calves for breeding	
$FCAH_t$	Herd of female calves for breeding	€
$CASA_t$	Herd of calves for slaughtering still alive at the end of the year $t$	€
$XLCA_t$	Exports of live calves	€
$CASW_t$	Calf average slaughter weight	
$NPVE_t$	Net production of veal	
$IPCA_t$	Index of producer price of calves	
<i>Female animals older than one year</i>		
$HEHE_t$	Herd of heifers	
$XLHE_t$	Exports of heifers	
$XNLHE_t$	Net exports of heifers	€
$SLHE_t$	Number of heifers slaughtered	
$HASW_t$	Heifer average slaughter weight	
$NPHE_t$	Net production of heifers	
$DAHE_t$	Herd of dairy cows	
$SUHE_t$	Herd of suckler cows	
$SLCO_t$	Number of cows slaughtered	
$COASW_t$	Cow average slaughter weight	
$NPCO_t$	Net production of cows	
<i>Male animals older than one year</i>		
$MAHE_t$	Herd of male adult animals (over than 1 year)	
$SLMA_t$	Number of male adult animals slaughtered	
$SLXMBU_t$	Number of male adult animals slaughtered and net exported	
$SLST_t$	Number of steers slaughtered	
$XNLMAC_t$	Net exports of male adult animals	€
$SLBU_t$	Number of bulls slaughtered	€
$BUASW_t$	Bull average slaughter weight	
$STASW_t$	Steer average slaughter weight	
$NPBU_t$	Net production of bulls	
$NPST_t$	Net production of steers	
$NPAC_t$	Net production of adult cattle	€
$IPCT_t$	Index of producer price of adult cattle	

### 9.2.3. The data used

All equations of the four national models are estimated econometrically. Required data are national times series data for all endogenous and exogenous variables of the model (mainly, herds, slaughterings, net productions, trade, prices, policy instruments, etc.... for each category of animals). The completed database is made up of aggregate annual data mainly issued from the NewCronos-Eurostat database, from 1973 to 1998.

### 9.3. Estimation results

Direct estimation results, that is equation by equation, are presented first. Then, the main dynamic multipliers that can be computed are commented.

#### 9.3.1. Direct estimation results

Detailed estimation results are reported in appendix 3 for each country and for each category of animals. This paragraph summarises the main findings.

##### 9.3.1.1. Calf crop models

In all countries, the calf crop depends significantly on the expected real producer price of calves. But, as indicated by Table 9.2, the magnitude of obtained elasticities (calculated at the sample mean) differs across countries.

**Table 9.2. Elasticities of the calf crop with respect to the real price of calves**

France	Germany	Italy	United-Kingdom
0.38	0.21	0.94	0.08

The allocation of calves born during year  $t$  among slaughtering and breeding herds is (nearly) always significantly dependent on the total amount of first payments of male premiums. This variable has a negative effect on the choice in favour of slaughtering but a positive one in favour of breeding. However elasticities (only evaluated here at the concerned equation level) reflect different sensitivities across countries.

**Table 9.3. Elasticities of allocation in favour of slaughtering or breeding relative to the total amount of first payments of male premiums**

	France	Germany	Italy	United-Kingdom
Slaughtering herd	-0.11	-0.20	-0.06	-1.05
Breeding herd	0.10	0.03	-	0.05

The various values of these elasticities do not seem to be related to the national orientation of calf production, which is balanced between slaughtering and breeding in France and in Italy, but which is mainly in favour of breeding in Germany, and especially in the UK.

The rate of slaughtering determines which proportion of the herd of calves devoted to slaughtering is effectively slaughtered during the year  $t$ . Due to the biological seasonality of births of calves, this rate is nearly the same for each country, about 75%. The expected real price of calves has generally a negative effect on this rate (elasticity of  $-0.34$  for France and  $-0.22$  for the UK), reflecting the expectation of a continuation of a price change: for example, an increase in the calf price will encourage delaying slaughtering. But an inverse effect is observed in Italy: the elasticity of the slaughtering rate to the calf price is  $0.77$ , showing the interest to immediately benefit of an increase in this price.

The calf average slaughter weight is also different among countries, according to their main orientations of production. This average slaughter weight is very low (about  $40\text{kg cwe}^{135}$ ) in the UK, but this country does not breed calves to be slaughtered as calves, but for breeding. This average weight is higher for the other countries: about  $110$  to  $115\text{kg cwe}$  in France and in Germany, and nearly  $140\text{kg}$  in Italy. The elasticity of the slaughter rate to the real price of animal feed is also quite different among countries: this elasticity is  $-0.25$  in France and  $-0.16$  in Italy, but about  $-0.08$  in Germany.

Finally, the net production of calves is indirectly dependent on all these variables, through the rate of slaughtering and the average slaughter weight. The total effects will be analysed further.

#### *9.3.1.2. Models of female animals older than one year*

Rates of replacement and rates of slaughtering of adult animals are also significantly dependent on price effects, but not always with the same sign (see appendix 3). For example the average elasticity of the rate of replacement of the heifer herd (that is the proportion of heifers which remain heifers the following year) with respect to the expected real price of adult cattle is  $-0.1$  in Germany, showing the interest not to delay slaughtering of heifers in case of an increase in price, but this elasticity is equal to  $0.1$  for Italy and  $0.4$  for the UK, showing the reverse effect.

Similar apparent contradictions can be observed for some other rates, for which interpretation of direct elasticities must be made cautiously (in the sense that they are evaluated within only one estimated equation, without taking into account possible indirect effects through other variables). These opposite

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<sup>135</sup> cwe = carcass weight equivalent.

effects may be only apparent, and only the further computation of total effects are conclusive in some cases.

For the cow herd, it is generally found that the milk quota has a positive effect on the dairy herd, that the suckler cow premium has sometimes a positive effect on the suckler herd, and that there is a substitution effect between dairy and suckler herds.

Effects on cow slaughterings are just derived from effects on cow herds, due to the low importance of trade for these categories of animals, for all countries.

### 9.3.1.3. Models of male animals older than one year

Effects of prices and policy variables on endogenous variables are more homogenous across countries in the case of adult male animals than for adult female animals. For example, the herd of adult male animals is assumed to be made up of: a proportion  $\gamma_t$  of the herd of male calves for breeding, and a proportion  $mrr_t$  of the adult male animals which were yet present the previous year. The rate  $\gamma_t$  is always positively dependent on: the total amount of the first payments of male premium ( $tap\_spma1_t$ ), and/or the expected real producer price of adult cattle ( $(\frac{ipct}{ipgdp})_{t-1}$ ). On the other hand, the rate of adult male replacement  $mrr_t$  is always positively dependent on: the total amount of the second payments of male premium ( $tap\_spma2_t$ ), and/or the expected real producer price of adult cattle (see Table 9.4).

**Table 9.4. Effects of prices and policy variables on adult cattle**

Effects on	$\gamma_t$		$mrr_t$		
	of	$tap\_spma1_t$	$(\frac{ipct}{ipgdp})_{t-1}$	$tap\_spma2_t$	$(\frac{ipct}{ipgdp})_{t-1}$
<b>France</b>		+	+	+	+
<b>Germany</b>		+		+	+
<b>Italy</b>		+		+	+
<b>United-Kingdom</b>			+		+

Effects on the total slaughterings of male adult cattle are derived from effects on inventories. Specific effects on bull and steer slaughterings, respectively, may be influenced by premiums granted to these categories of animals. The effect of the total premiums granted either to bulls or to steers on the rate of slaughtering is always negative (see Table 9.5). That reflects the opportunity of capitalising rather than slaughtering the cattle in case of an increase in the total amount of these premiums (which can be due to an increase in the number of premiums, or in the unitary level). Note that this effect is always very small for bulls, but more important for steers.

**Table 9.5. Elasticities of the rate of slaughtering of bulls and steers with respect to the total amount of premiums granted to these animals**

	bulls	steers
<b>France</b>	-0.01	-0.46
<b>Germany</b>	-0.02	-0.60
<b>Italy</b>	-0.01	-
<b>United-Kingdom</b>	-	-1.18

Generally, the average slaughter weights of all animals are significantly affected by a positive time trend effect (through a positive effect of the lagged slaughter weight) and by a negative effect of the price of animal feed. However, elasticities of the slaughter weights to this price are not very large (see Table 9.6).

**Table 9.6. Short-run elasticities of average slaughter weights with respect to the real price of animal feed**

	Heifers	Cows	Bulls	Steers
<b>France</b>	-0.08	-	-0.11	-0.10
<b>Germany</b>	-0.08	-0.06	-0.06	-0.10
<b>Italy</b>	-0.09	-0.04	-0.12	-0.01
<b>United-Kingdom</b>	-0.05	-0.05	-0.06	-

Real indexes of producer prices are modelled as linear functions of the real intervention price, expressed in national currency, and of the excess supply. These indexes are positively correlated with the intervention price, and negatively dependent on the excess supply (calculated as the difference between the net production and the domestic consumption). Elasticities of producer prices to the intervention price, in real terms, are reported in Table 9.7.

**Table 9.7. Elasticities of real producer prices to the real intervention price**

	Calves	Adult cattle
<b>France</b>	1.12	0.59
<b>Germany</b>	1.09	0.85
<b>Italy</b>	0.73	1.47
<b>United-Kingdom</b>	0.97	1.29

### 9.3.2. Dynamic elasticities

Contrary to previous direct elasticities which are calculated *ceteris paribus*, multipliers and dynamic elasticities take into account all direct and indirect simultaneous and over time effects, within the whole model, of a given exogenous variable on a given endogenous variable. Therefore, their interpretation is more explicit. It is theoretically possible to compute dynamic elasticities of key variables of the model (such as cattle or net productions) to any exogenous variable of the model (such as the number of premiums granted, the unitary level of one premium, the milk quota, the intervention price, etc.). When the model is linear of the form:  $Y_t = AY_{t-1} + \Gamma_0 X_t + \Gamma_1 X_{t-1}$ , where  $Y_t$  is the vector of endogenous variables and  $X_t$  the vector of exogenous variables, then the matrix of impact multipliers is  $\Gamma_0$ . The effect at  $t+n$  of an exogenous shock in  $t$  is measured by the matrix of interim multipliers of order  $n$ :  $INTER_n = A INTER_{n-1} = A^{n-1}(\Gamma_1 + A\Gamma_0)$ , while the matrix of total multipliers (i.e.,  $INTER_n$  with  $n \rightarrow \infty$ ) is  $TOTAL = (I - A)^{-1}(\Gamma_0 + \Gamma_1)$ . Matrices of dynamic elasticities can then be derived from these multipliers (whether impact, interim or total) by multiplying each term ( $g,k$ ) of any matrix by  $\frac{X_{kt}}{Y_{g,t+s}}$ , where  $s = 0, 1, \dots, \infty$  (elasticities are generally computed at the sample mean point).

Here, the model is not linear, because of the logistic specification of numerous relationships, but also because of the fact that net production variables are the product of two other endogenous variables, the average slaughter weight and the slaughterings expressed in number of heads. Due to these nonlinearities, an analytic determination of these dynamic elasticities is not easily tractable. Thus, a simulation method was preferred. The adopted method may be described as follows.

First a reference baseline projection is simulated on the period 2000-2010. The values of (exogenous) policy variables (unitary premiums, intervention price, milk quota) are those decided within the Agenda 2000 final decisions until 2002 (2005/2006 for the milk quota).<sup>136</sup> They are assumed to remain unchanged after this date. Nevertheless, the numbers of premiums (i.e., the number of first and second payments for the male premium and the number of suckler cow premiums) are known only until 1999. Thus, they are assumed to remain at their observed 1999 level over the whole projection period. Changes in beef and veal consumption in the four considered countries are based on the assumption that per capita consumption goes on decreasing according to past observed trends. This assumption results in the per capita consumption levels reported in Table 9.8 for 2000 and 2010. To

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<sup>136</sup> Note that new policy instruments (such as the implementation of an aid scheme for private storage from 2002 on, which will take over from intervention, or the introduction of a slaughter premium), or instruments which are not introduced in the model (such as the extensification premium), are not taken into account in neither the baseline projection, nor the scenario of changes in the number of premiums. This *ceteris paribus* condition makes the computation of the dynamic elasticities reliable.

approximate the total consumption, the population is assumed to keep on increasing in France and in the United-Kingdom, but decreasing in Germany and Italy (FAO assumptions).

**Table 9.8. Beef and veal assumed per capita consumption levels (Kg/head)**

	Beef		Veal	
	2000	2010	2000	2010
<b>France</b>	22.4	20.9	4.8	4.2
<b>Germany</b>	13.8	10.3	1.2	1.2
<b>Italy</b>	20.4	18.5	3.8	3.5
<b>United-Kingdom</b>	15.3	11.0	0.1	0.1

Other exogenous variables (price of animal feed, price index of gross domestic product, and imports of live animals except bulls) are assumed to remain stable relative to the recent period.

The second step consists of making a variantial scenario involving a shock on one chosen exogenous variable in the first year of the simulation period (all other exogenous variables remaining unchanged relatively to the baseline scenario). A shock of 1% is applied to this variable in the first year, and this number recovers its initial level the following years.<sup>137</sup> Then, year after year, changes in every endogenous variable can be compared to baseline scenario levels, and can be expressed in terms of elasticities.

This exercise is carried out for the following key exogenous variables:

- the number of male premiums,
- the number of suckler cow premiums
- the level of the intervention price.

Effects are mainly observed on cattle (for the various categories), net productions, and prices.

#### *9.3.2.1. Elasticities to the number of male premiums*

In all countries, the instantaneous effect (measured by the short-run or impact elasticity) of the number of male premiums is positive on net production of veal and negative, but nearly nil, on net production

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<sup>137</sup> The purpose here is not to assess the effect of a sustained change in an exogenous variable, such as the number of premiums for example, which would actually be the real consequence of a policy reform, but to compute elasticities of key variables to the number of premiums. In this aim, it is necessary that the number of premiums recovers its previous level, after the shock.

of beef (cf. Table 9.9).<sup>138</sup> The long-run (or cumulative) elasticities remain negative for the net production of veal in all countries except France, where the long-run effect is zero. More importantly, the long-run elasticity of the net production of beef to the number of male premiums is positive and about 0.4 for France and Germany, but nearly zero for Italy and the United-Kingdom. This suggests that in the four countries, the number of male premiums has relatively low effects on the net production of beef.

**Table 9.9. Elasticities of the net production of beef and veal with respect to the number of male premiums**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	-0.25	0.00	-0.03	0.40
<b>Germany</b>	-0.41	-0.19	0.05	0.45
<b>Italy</b>	-0.19	-0.35	-0.02	-0.08
<b>United-Kingdom</b>	-1.68	-1.66	-0.00	0.06

In all countries, the instantaneous effect of the number of male premiums on cattle is zero for both calves and adult cattle (cf. Table 9.10). The long-run elasticity of calf herd is positive in all countries but Italy. The long-run elasticities of adult cattle are logically of the same sign than the long-run elasticities of the net production of beef. The value is exactly the same for France (0.40), but lower in Germany (0.23 as compared to 0.45 for the long-run elasticity of beef net production).

**Table 9.10. Elasticities of herds with respect to the number of male premiums**

	Calves		Adult cattle	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.05	0.45	0.02	0.40
<b>Germany</b>	0.03	0.25	0.01	0.23
<b>Italy</b>	-0.03	-0.18	0.02	-0.16
<b>United-Kingdom</b>	0.01	0.07	0.00	0.06

The elasticities of producer prices to the number of male premiums generally reflect the effects of these premiums on net productions. For example, in France and Germany, the impact elasticities of the net production of veal with respect to the number of male premiums are negative. Meanwhile, the

<sup>138</sup> As regards to net production of veal, the elasticities estimated for UK must be considered with caution due to the very low production of veal in this country.

corresponding elasticities for the producer prices of veal are positive. One notes the same converse relationship for long-run elasticities, still for France and Germany. They are positive for net production of beef and negative for the beef producer prices. Table 9.11 shows that the long-run elasticities of the producer prices of both veal and beef are nearly nil for Italy and the UK. These results suggest that, for example, a decrease in the number of male premiums will induce a slight increase in the producer prices of beef and veal in France and Germany, but will have nearly no effect on these prices in Italy and the UK.

**Table 9.11. Elasticities of the producer prices of beef and veal with respect to the number of male premiums**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.35	-0.03	0.03	-0.46
<b>Germany</b>	0.17	0.09	-0.03	-0.25
<b>Italy</b>	0.00	0.00	0.01	0.07
<b>United-Kingdom</b>	0.03	0.03	0.00	-0.06

These global effects may recover contrasted, and sometimes opposite effects, according to the categories of animals. For example, In France, the long-run elasticity of the net production of beef to the number of male premiums is 0.4. In fact, this elasticity is 0.71 for net production of bull meat, 0.66 for heifers, 0.35 for cows, but the effect is negative on steer production, with an elasticity of -1.0.

#### 9.3.2.2. Elasticities to the number of suckler cow premiums

A shock applied to the number of suckler cow premiums has effects on productions, prices, and herds, but only some years after this shock has been implemented. Instantaneous effects are always nearly zero. The long-run elasticities of net production are positive for both veal and beef (cf. Table 9.12). In turn, the corresponding elasticities of producer prices are negative. However, effects on prices are rather low, and sometimes nearly zero (cf. Table 9.14).

Long-run elasticities of calf herd and adult cattle to the number of suckler cow premiums are generally very close to those relative to net production of veal and beef. Globally, elasticities of net production of veal and beef and of cattle are not very large, except in Germany. Note that the direct elasticity of suckler herds to the number of suckler cow premiums is about 1.5 in Italy (but the suckler herd accounts for only 20% of the total cow herd in Italy), 0.7 in Germany, only 0.3 in France and zero in the UK.

**Table 9.12. Elasticities of the net production of beef and veal to the number of suckler cow premiums**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.00	0.17	-0.07	0.12
<b>Germany</b>	0.00	0.50	-0.00	0.35
<b>Italy</b>	0.00	0.29	-0.03	0.09
<b>United-Kingdom</b>	0.00	0.11	0.00	0.07

**Table 9.13. Elasticities of herds to the number of suckler cow premiums**

	Calves		Adult cattle	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.00	0.13	0.02	0.22
<b>Germany</b>	0.00	0.50	0.00	0.52
<b>Italy</b>	0.00	0.25	0.02	0.27
<b>United-Kingdom</b>	0.00	0.17	0.00	0.16

**Table 9.14. Elasticities of producer prices of beef and veal with respect to the number of suckler cow premiums**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
France	0.00	-0.25	0.07	-0.16
Germany	0.00	-0.17	0.00	-0.17
Italy	0.00	-0.00	0.02	-0.08
United-Kingdom	0.00	-0.00	0.00	-0.14

#### 9.3.2.3. Elasticities to the intervention price

Instantaneous elasticities of the producer prices of beef and veal to the intervention price (expressed in national currencies) are naturally close to those which are directly derived from the estimated beef and veal price equations (due to the linear form of these equations, and because the intervention price appears only in these price equations). They indicate that generally a shock in the intervention price is nearly entirely transmitted to the producer prices of veal and beef at the same period (cf. Table 9.15). Due to lagged effects on production, the corresponding long-run elasticities are lower. Furthermore, in the case of France, the long-run elasticity of the beef price to the intervention price is negative: the

effect is positive in the first year, but this positive effect is compensated by negative effects in the following years. This is due to the fact that the expected producer price has negative effects on adult male slaughterings, which are higher in France than in other countries. These negative effects overcompensate the positive effects induced by the cattle increase. Finally, the total compensation of the instantaneous positive effect occurs after about ten years. Moreover the computation of cumulative effects on a longer period leads to a negative long-run elasticity.

**Table 9.15. Elasticities of the producer prices of beef and veal with respect to the intervention price**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.96	0.11	0.61	-0.16
<b>Germany</b>	1.00	0.70	0.95	0.42
<b>Italy</b>	0.68	0.68	0.82	0.64
<b>United-Kingdom</b>	1.08	1.07	1.79	1.48

A change in the intervention price affects the net production of beef and veal and cattle only during the years following the shock. The main reason is that the intervention price first affects the producer prices, which, in turn, modify all producers' decisions with a time lag. In all countries, the long-run elasticities of the net production of veal with respect to the intervention price are positive (cf. Table 9.16). They are close to one in Germany, Italy and the UK, but only 0.6 for France. The long-run elasticities of the net production of beef are positive in all countries too. They are higher in France (0.7) and Germany (1.0) than in Italy and the U.K. (0.2 to 0.3). Similar effects on calf and adult cattle are observed, but elasticities are more homogeneous across countries: except for the UK, the elasticities of calf herds are about 0.6 to 0.8 in all countries, while elasticities of adult cattle are about 0.7 (cf. Table 9.17).

**Table 9.16. Elasticities of the net production of beef and veal with respect to the intervention price**

	Veal		Beef	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.00	0.58	0.00	0.67
<b>Germany</b>	0.00	0.83	0.00	1.00
<b>Italy</b>	0.00	0.81	0.00	0.20
<b>United-Kingdom</b>	0.00	1.10	0.00	0.30

**Table 9.17. Elasticities of herds to the intervention price**

	Calves		Adult cattle	
	<i>Impact</i>	Long-run	<i>Impact</i>	Long-run
<b>France</b>	0.00	0.69	0.00	0.65
<b>Germany</b>	0.00	0.83	0.00	0.73
<b>Italy</b>	0.00	0.55	0.00	0.75
<b>United-Kingdom</b>	0.00	0.35	0.00	0.34

Finally, it appears that the intervention price has more significant effects on the various endogenous variables than the number of premiums granted. For example in France, the long-run elasticity of the net production of beef to the intervention price is 0.65, while the long-run elasticities of this variable with respect to the number of male premiums and to the number of suckler cow premiums are, respectively, only 0.4 and 0.12. Similar conclusions can be made for the other countries, even if in some cases the respective elasticities have very low values.

#### **9.4. Policy simulations**

The national models have been used to simulate two basic policy scenarios. The first one is the baseline scenario. As this baseline scenario includes the policy changes adopted within the Agenda 2000 reform, it allows to analyse the impacts of this reform on the considered national beef and veal sectors. The second scenario focuses on one key instrument of the beef and veal CMO: the headage payment system. In order to shed some light on the potential impacts of restricting the current premium scheme (through a decrease in the various ceilings currently in force, such as the number of eligible animals or the intensity ceiling for example), this second scenario assumes a –20% decrease in the number of premiums granted to farmers.

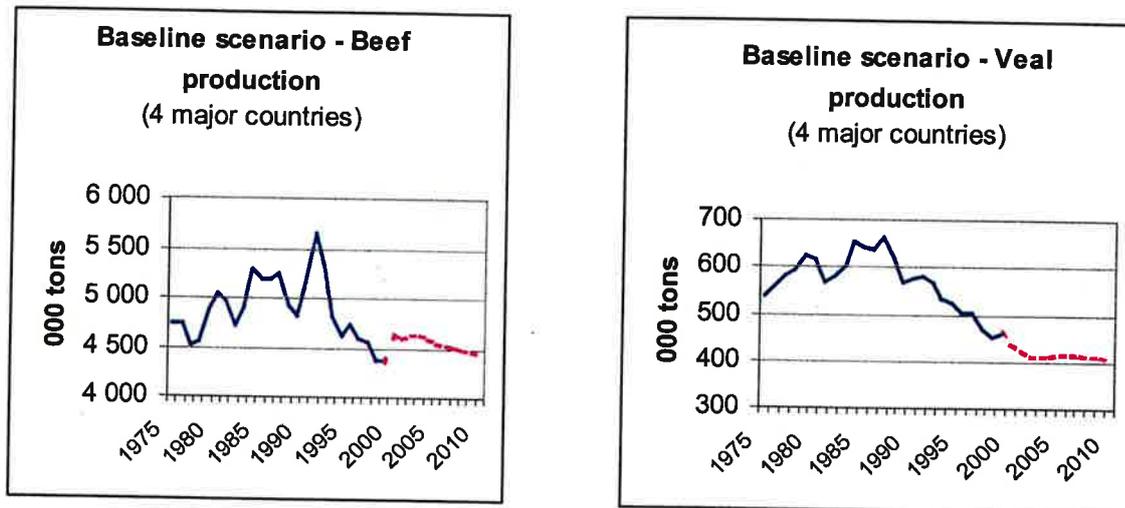
##### ***9.4.1. The baseline scenario: The impacts of the Agenda 2000 reform***

The baseline scenario relies on the same hypotheses than the one adopted for computing the dynamic elasticities. Hence, globally, this scenario consists in the application of the Agenda 2000 final decisions from 2000 to 2002 and a continuation of this policy afterwards (i.e., until 2010). For example, the levels of the unitary premiums decided in the Agenda 2000 reform are applied from 2000 to 2010 since they are assumed unchanged after the reform is implemented. A similar assumption is adopted regarding the number of premiums granted. For each country and each category of animals, they are assumed to remain at their 1999 until the end of the projection period (i.e., 2010).

For the aggregated four countries (which account for about 60 to 65% of the EU15 beef and veal production), this baseline scenario induces first a significant increase in the beef production until 2003,

then a decrease until 2010 (-3.9%). These converse movements result in a slight increase over the 10 years projection horizon (+2.4%). For veal production, the baseline scenario leads to a significant decrease until 2003 (-9.9%), and then a relative stability resulting in a -10.7% decrease over the whole period.

**Figure 9.1. The impacts of the baseline scenario on beef and veal production at the four countries aggregated level**



The baseline scenario induces differentiated changes in the four considered countries. For beef, France and UK experience an increase in production over the projection period. This increase is about +4% in France and +43% in the UK (but it concerns a less important quantity). These increases are roughly compensated by an important decrease in Germany (-19.8%). The adjustment of veal production over the projection period is negative for all countries, but with different magnitudes: -9.6% in France, -27.5% and Germany, and -5.1% in Italy (net production of veal is nearly zero in the UK).

**9.4.2. The restrictive premium scheme scenario: The impacts of a -20% decrease in the number of premiums granted**

The restrictive premium scheme scenario rely on the same assumptions than the baseline scenario except the one relating to the number of premiums granted. In the baseline scenario, the numbers of the various premiums granted to farmers are assumed to remain unchanged with respect to their 1999 observed levels, over the whole projection period. This concerns the number of first and second payments of the male premium and the number of annual payments of the suckler cow premium. The restrictive premium scheme scenario assumes a -20% decrease in the total number of premiums granted (the number of first and second payments for male animals, and the number of suckler cow premiums) during the first year of the simulation period. Note that in this scenario the change in the number of premiums is maintained all over the simulation period. National models provide the effects

of this policy change on all endogenous variables (cattle, net production, prices). In this paragraph, we report and discuss the simulated effects on net productions only because they give a synthetic picture of the overall induced adjustments within the national supplying beef and veal sectors

Computed dynamic elasticities, particularly of net productions with respect to the number of premiums granted, already suggested that this policy instrument has a low impact on beef and veal supply in the four considered countries. The simulation results of the restrictive premium scheme scenario confirms this conclusion. The effects of this scenario on net production of beef and veal, relative to the baseline scenario, are reported in table 9.18.

**Table 9.18. The effects of a -20% decrease in the number of premiums granted on net production of beef and veal (relative to the baseline scenario)**

	Net production of veal		Net production of beef	
	2003	2010	2003	2010
France	+4.3%	-0.8%	-1.4%	-8.3%
Germany	+10.2%	+3.0%	-4.3%	-9.5%
Italy	+3.5%	+1.8%	+0.4%	-0.2%
United-Kingdom	<i>n.s.</i>	<i>n.s.</i>	+0.1%	-1.8%
<b>Total</b>	<b>+4.4%</b>	<b>+0.3%</b>	<b>-1.5%</b>	<b>-5.3%</b>

*n.s.*: no significant

Simulation results show that even a drastic reduction in the number of premiums has nearly no effect on the net production of veal at the aggregate level. The -20% decrease in the number of premiums induces a decrease in the net production of beef, but, at the aggregate level, this decrease remains relatively limited (-1.5% until 2003 and -5.3% over the whole projection period). The decrease observed at the aggregate level results mainly from slightly more important decreases experienced in France and Germany (-8.3% and -9.5%, respectively), Italy and the UK being nearly no affected by the policy change.

The policy change that is simulated in this scenario is a cut-off in the number of all premiums. Effects are differentiated among countries, but also among categories of animals. This last finding indicates that a change in the awarding of premiums may have more significant consequences if it is targeted on specific categories of animals. However, such targeted changes would probably induce cross effects among categories of animals, such that impacts on targeted categories of animal could be partially compensated by effects on other categories of animals.

Finally, one of the main findings of the present study, either through the computation of dynamic elasticities or through the analysis of the impacts of policy reform scenarios, is that direct payment

such as the beef premium scheme in force in the CMO for beef and veal are rather decoupled in the sense that they induce relatively low effects on production.

### **9.5. Conclusion and policy recommendations**

A complete model of the beef and veal producing sector has been estimated for the four major producing Member States. Each model focuses on the effects of economic and agricultural policy variables on behavioural and biological relationships. Such models may be used to make simulations of policy changes in the beef sector, that is mainly, of changes in direct aids (both unitary premiums and the number of premiums granted), in milk quotas, or in the intervention price.

To assess the effects of such policy changes, the dynamic elasticities of the main endogenous variables (cattle, production, and prices) with respect to the policy variables are computed through a simulation method. They show, for example, that the number of premiums granted has no sizeable effects on net productions of beef and veal, but that effects of the intervention price are more significant.

Then, an issue which is addressed here is the assessment of a more restrictive awarding of direct aids through a cut-off in the number of premiums granted. Simulation results suggest that a change in the number of premiums granted does not have a sizeable effect on net productions of beef and veal, although impacts on herds and net productions vary across the various categories of animals and among countries. A change in the number of male premiums has an incidence only on beef production, not on veal production, but this effect is relatively limited.

Responses of the main European producing countries to policy changes are not homogenous. But, generally and naturally, effects observed at the aggregate level are close to the ones observed in France, which is the first producing Member State for both veal and beef.

One of the main results that can be drawn on our analysis is that the number of premiums (that is essentially the density ceilings) is not an efficient instrument for regulating the EU supply of beef and veal. Therefore, in order to affect significantly the beef and veal supply, the number of premiums should not be used alone, but in conjunction with other policy instruments.

## APPENDIX 1.

### Structure of the national models

The structure of the French model is presented. Some slight differences may occur for models of other countries. In this case, they are mentioned in appendix 3 when presenting the estimation results.

Names of endogenous variables are given in Table 9.1.

#### Calves

$$BICA_t = cc_t (HEHE_{t-1} + COHE_{t-1})$$

$$CASL_t = csl_t \cdot BICA_t$$

$$CABR_t = cbr_t \cdot BICA_t$$

$$SLCA_t = slr_t \cdot CASL_t$$

$$MCAH_t = mal_t \cdot CABR_t$$

$$FCAH_t = CABR_t - MCAH_t$$

$$XLCA_t = BICA_t + MLCA_t - CAHE_t - 1.02 \cdot SLCA_t + CASA_{t-1}$$

$$CAHE_t = CABR_t + CASL_t - SLCA_t$$

$$CASA_t = CASL_t - SLCA_t$$

#### Bovine female animals older than 1 year

$$HEHE_t = FCAH_{t-1} + hrr_t \cdot HEHE_{t-1}$$

$$(SLHE_t + XLHE_t - MLHE_t) = hsx_t \cdot HEHE_{t-1}$$

$$SLHE_t = hsl_t \cdot (SLHE_t + XLHE_t - MLHE_t)$$

$$DAHE_t = (1 - hrr - hsx_t) \cdot HEHE_{t-1} \cdot \frac{DAHE_{t-1}}{COHE_{t-1}} + dhrr_t \cdot DAHE_{t-1}$$

$$SUHE_t = (1 - hrr - hsx_t) \cdot HEHE_{t-1} \cdot \frac{SUHE_{t-1}}{COHE_{t-1}} + shrr_t \cdot SUHE_{t-1}$$

$$SLCO_t = (1 - dhrr_t) \cdot DAHE_{t-1} + (1 - shrr_t) \cdot SUHE_{t-1}$$

#### Bovine male animals older than 1 year

$$MAHE_t = \gamma_t \cdot MCAH_{t-1} + mrr_t (MAHE_{t-1} - XNLMA_t)$$

$$SLMA_t = (1 - \gamma_t) \cdot MCAH_{t-1} + (1 - mrr_t) \cdot (MAHE_t + MLCA_t - XNLMA_t)$$

$$SLMA_t = SLBU_t + SLST_t$$

$$SLBU_t + XNLMA_t = buslx_t \cdot MAHE_{t-1}$$

$$SLST_t = stsl_t \cdot MAHE_{t-1}$$

$$SLBU_t = busl_t \cdot (SLBU_t + XNLMA_t)$$

### Net production of veal and adult cattle

$$NPVE_t = casw_t \cdot SLCA_t$$

$$NPHE_t = hasw_t \cdot SLHE$$

$$NPCO_t = coasw_t \cdot SLCO_t$$

$$NPBU_t = buasw_t \cdot SLBU$$

$$NPST_t = stasw_t \cdot SLST_t$$

$$NPAC_t = NPHE_t + NPCO_t + NPBU_t + NPST_t$$

### Specification of the key variables of the model

#### The various rates

$$y = \{ cc, csl, cbr, slr, mal, hrr, hsx, hsl, dhrr, shrr, \gamma, mrr, buslx, bosl, busl \}$$

$$y_t = \frac{y^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

where:  $y^+$  is the upper limit chosen for  $y$ ,  
 $X_t$  is a vector of explanatory variables  
 $\beta$  is a vector of parameters,  
 $\varepsilon_t$  is an error term.

#### The average slaughter weights

$$\text{Calves: } casw_t = \frac{casw^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

$$\text{Heifers: } hasw_t = \frac{hasw^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

$$\text{Cows: } coasw_t = \frac{coasw^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

$$\text{Bulls: } buasw_t = \frac{buasw^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

$$\text{Steers: } stasw_t = \frac{stasw^+}{1 + \exp(-X_t \beta)} + \varepsilon_t$$

#### indexes of producer prices

$$\text{Calves: } \left( \frac{ipca}{ipgdp} \right)_t = X_t \beta + \varepsilon_t$$

$$\text{Adult cattle: } \left( \frac{ipct}{ipgdp} \right)_t = X_t \beta + \varepsilon_t$$

## APPENDIX 2.

### List of the exogenous variables

$ipgdp_t$	Price index of gross domestic product (1990=100)
$ipfeed_t$	Animal feed price index
$tap\_spma1_t$	Total amount of the <b>first</b> payment of the special premium for male animals (bulls and steers)
$tap\_spma2_t$	Total amount of the <b>second</b> payment of the special premium for male animals (bulls and steers)
$tap\_bu_t$	Total amount of the special premium for bulls
$tap\_st_t$	Total amount of the special premium for steers
$tap\_scp_t$	Total amount of suckler cow premiums
$milk_t$	Milk quota (assumed equal to the milk collected, before 1984)
$intp_t$	Nominal intervention price

Each variable "total amount of premiums" ( $tap\_*$ ) is the product of the number of premiums granted by the unitary level of the premium.

APPENDIX 3.

Estimation results

**FRANCE**

(t-statistics are provided in parenthesis)

**Table 9.19. Estimation results for the calf model**

	Calf crop ( $cc^+=0.7$ )	Calves for slaughtering ( $csl^+=0.75$ )	Slaughtering rate ( $slr^+=0.95$ )	Calves for breeding ( $cbr^+=0.75$ )	Male calves for breeding ( $mal^+=0.50$ )	Average slaughter weight ( $casw^+=130$ )
Constant	-2.926 (-2.84)	0.518 (15.5)	1.235 (3.72)	1.039 (20.8)	1.280 (1.04)	0.519 (0.13)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$	1.794 (5.39)		-1.594 (-2.14)		-1.083 (-2.84)	
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$			1.607 (3.60)			
$milk_t$					0.474.10 <sup>-4</sup> (1.18)	
$milk_{t-1}$	0.102.10 <sup>-3</sup> (3.17)					
$tap\_spmal_t$		-0.334.10 <sup>-6</sup> (-5.93)		0.538.10 <sup>-6</sup> (6.41)		
$casw_{t-1}$						0.036 (1.44)
$\left(\frac{ipfeed}{ipgdp}\right)_{t-1}$						-2.032 (-2.29)
R <sup>2</sup>	0.59	0.65	0.61	0.70	0.46	0.87
DW	1.48	0.81	0.91	1.07	1.76	1.15

**Table 9.20. Estimation results for heifers for slaughtering and export**

$X_t$	$bsx_t$ ( $bsx^+=0.3$ )
Constant	3.745 (2.80)
$milk_t$	-0.614.10 <sup>-4</sup> (-1.58)
$tap\_scp_t$	-0.383.10 <sup>-6</sup> (-3.61)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-1.268 (-2.81)
	R <sup>2</sup> = 0.40 DW = 1.97

**Table 9.21. Estimation results for the rates of cow replacement**

$X_t$	dairy herd $dhrr_t$ ( $dhrr^+ = 0.9$ )	suckler herd $shrr_t$ ( $shrr^+ = 0.9$ )
Constant	1.745 (25.03)	2.086 (17.02)
$milk_t - milk_{t-1}$	$0.240 \cdot 10^{-4}$ (1.89)	
$DAHE_t - DAHE_{t-1}$		$-0.123 \cdot 10^{-2}$ (-2.11)
	$R^2 = 0.14$ $DW = 1.75$	$R^2 = 0.17$ $DW = 2.19$

**Table 9.22. Estimation results for the heifer and cow average slaughter weights**

$X_t$	Heifers ( $hasw^+ = 370$ )	$X_t$	Cows ( $coasw^+ = 350$ )
Constant	-3.726 (-3.35)	Constant	-8.704 (-19.38)
$hasw_{t-1}$	0.019 (7.24)	$coasw_{t-1}$	0.035 (24.1)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.456 (-1.90)		
	$R^2 = 0.97$ $DW = 0.80$		$R^2 = 0.96$ $DW = 1.96$

**Table 9.23. Estimation results for the herd of adult males**

$X_t$	$\gamma_t$ $\gamma^+ = 0.55$	$mrr_t$ $mrr^+ = 1.$
Constant	-3.756 (-1.40)	0.060 (0.09)
$tap\_spma1_t$	$0.221 \cdot 10^{-5}$ (1.73)	
$tap\_spma2_t$		$0.317 \cdot 10^{-6}$ (0.59)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	4.584 (1.99)	0.404 (1.04)
	$R^2 = 0.96$ $DW = 2.14$ $RMSE = 3.23\%$	

**Table 9.24. Estimation results for the rates of slaughtering (plus export for bulls) of adult males**

$$(XNLMA_t = XLMA_t - MLMA_t) \text{ (assume } XLST_t = MLST_t = 0 \Rightarrow XNLMA_t = XLBU_t - MLBU_t)$$

$$(SLXMBU_t = XNLMA_t + SLBU_t)$$

$XLBU_t$  and  $MLBU_t$  are respectively exports and imports of bulls,

$XLST_t$  and  $MLST_t$  are respectively exports and imports of steers

$$SLXMBU_t = buslx_t \cdot (MCAH_{t-1} + MAHE_{t-1})$$

$$SLST_t = stsl_t \cdot (MAHE_{t-1})$$

$$SLBU_t = SLMA_t - SLST_t$$

$$XNLMA_t = SLXMBU_t - SLBU_t$$

$X_t$	Bulls ( $buslx^+ = 1.$ )	$X_t$	Steers ( $stsl^+ = 0.9$ )
Constant	1.033 (2.79)	Constant	1.467 (2.01)
$tap\_bu_t$	$-0.199 \cdot 10^{-7}$ (-0.10)	$tap\_st_t$	$-0.227 \cdot 10^{-5}$ (-7.87)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-1.429 (-5.19)	$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-0.715 (-1.94)
		$slbu_{t-1}$	$-0.113 \cdot 10^{-2}$ (-3.19)
	$R^2=0.82$ $DW=0.90$		$R^2=0.94$ $DW=1.52$

**Table 9.25. Estimation results for the bull and steer average slaughter weights**

$X_t$	Bulls ( $buasw^+ = 550$ )	$X_t$	Steers ( $stasw^+ = 550$ )
Constant	-0.687 (-1.74)	Constant	-0.719 (-1.35)
$buasw_{t-1}$	$0.479 \cdot 10^{-2}$ (5.55)	$stasw_{t-1}$	$0.489 \cdot 10^{-2}$ (4.27)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.301 (-4.35)		-0.274 (-3.13)
	$R^2=0.96$ $DW=1.33$		$R^2=0.96$ $DW=1.69$

**Table 9.26. Estimation results for the real indexes of producer prices (national currencies)**

	Calves	Adult cattle
Constant	-0.229 (-0.99)	0.276 (1.62)
Real intervention price expressed in national currency	$0.431 \cdot 10^{-3}$ (5.22)	$0.245 \cdot 10^{-3}$ (2.86)
Excess supply	$-0.501 \cdot 10^{-2}$ (-4.37)	$-0.556 \cdot 10^{-3}$ (-8.16)
	$R^2 = 0.88$ $DW = 1.56$	$R^2 = 0.98$ $DW = 2.40$

**GERMANY**

(t-statistics are provided in parenthesis – for nearly all relationships, a dummy variable equal to 1 in 1991 and zero otherwise is introduced to take into account the German reunification, but the corresponding coefficients are not reported here)

**Table 9.27. Estimation results for the calf model**

	Calf crop ( $cc^+ = 0.85$ )	Calves for slaughtering ( $csI^+ = 0.2$ )	Slaughtering rate (fixed)	Calves for breeding ( $cbr^+ = 1.$ )	Male calves for breeding ( $mal^+ = 0.50$ )	Average slaughter weight ( $casw^+ = 130$ )
Constant	0.336 (2.44)	1.294 (9.97)	0.75	1.853 (25.0)	3.495 (37.9)	-3.910 (-2.35)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$	0.978 (8.48)					
$tap\_scp_t$					$-0.692 \cdot 10^{-5}$ (-4.58)	
$tap\_spmal_t$		$-0.248 \cdot 10^{-5}$ (-3.66)		$0.917 \cdot 10^{-6}$ (2.36)		
$casw_{t-1}$						0.056 (4.95)
$\left(\frac{ipfeed}{ipgdp}\right)_{t-1}$						-0.194 (-0.57)
R <sup>2</sup>	0.91	0.39		0.21	0.63	0.81
DW	1.04	1.14		1.25	0.90	1.54

**Table 9.28. Estimation results for heifer cattle (*hehe*)**

$$HEHE_t = rdfc_t \cdot FCAH_{t-1} + hrr_t \cdot HEHE_{t-1}$$

$X_t$	$rdfc_t$ ( $rdfc^+ = 0.98$ )	$hrr_t$ ( $hrr^+ = 0.4$ )
Constant	2.349 (19.0)	1.173 (10.4)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$	-0.920 (-8.91)	
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$		-0.267 (-3.25)
	$R^2 = 0.97$ $DW = 1.55$	$R^2 = 0.82$ $DW = 0.85$

**Table 9.29. Estimation results for heifers for slaughtering and export**

$$SLHE_t + XLHE_t - MLHE_t = bsx_t \cdot FCAH_{t-1} + \beta_t \cdot HEHE_{t-1}$$

$X_t$	$bsx_t$ ( $bsx^+ = 1.3$ )	$\beta_t$ ( $\beta^+ = 0.4$ )
Constant	-3.955 (-14.8)	0.969 (3.11)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	1.405 (7.01)	-1.203 (-5.07)
	$R^2 = 0.92$ $DW = 1.49$	$R^2 = 0.59$ $DW = 1.14$

**Table 9.30. Estimation results for heifer slaughtering**

$$SLHE_t = hsl_t \cdot (SLHE_t + XLHE_t - MLHE_t)$$

$X_t$	$hsl_t$ ( $hsl^+ = 1.$ )
Constant	2.233 (3.62)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	0.837 (1.54)
	$R^2 = 0.22$ $DW = 0.43$

**Table 9.31. Estimation results for the rates of cow replacement**

$X_t$	dairy herd $dhrr_t$ ( $dhrr^+ = 1.$ )	suckler herd $shrr_t$ ( $shrr^+ = 1.$ )
Constant	0.873 (25.4)	1.006 (6.08)
$milk_t - milk_{t-1}$	$0.230 \cdot 10^{-3}$ (8.80)	$-0.304 \cdot 10^{-3}$ (-1.64)
$tap\_scp_t$		$0.381 \cdot 10^{-6}$ (0.14)
	$R^2 = 0.14$ $DW = 1.75$	$R^2 = 0.24$ $DW = 1.65$

**Table 9.32. Estimation results for the heifer and cow average slaughter weights**

$X_t$	Heifers ( $hasw^+=300$ )	$X_t$	Cows ( $coasw^+=300$ )
Constant	-0.683 (-0.33)	Constant	-2.383 (-0.62)
$hasw_{t-1}$	0.013 (1.82)	$coasw_{t-1}$	0.022 (1.69)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.541 (-2.87)	$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.743 (-3.59)
	$R^2=0.84$ $DW=2.01$		$R^2=0.81$ $DW=2.32$

**Table 9.33. Estimation results for the herd of adult males**

$X_t$	$\gamma_t$	$mrr_t$
	$\gamma^+=0.8$	$mrr^+=0.2$
Constant	0.858 (23.8)	-0.178 (-0.80)
$tap\_spma1_t$	$0.467 \cdot 10^{-6}$ (2.36)	
$tap\_spma2_t$		$0.612 \cdot 10^{-5}$ (2.73)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$		0.175 (1.12)
	$R^2=0.78$ $DW=1.21$	$R^2=0.57$ $DW=1.56$

**Table 9.34. Estimation results for the rates of slaughtering (plus export for bulls) of adult males**

$$(XNLMA_t = XLMA_t - MLMA_t) \text{ (assume } XLST_t = MLST_t = 0 \Rightarrow XNLMA_t = XLBU_t - MLBU_t)$$

$$(SLXMBU_t = XNLMA_t + SLBU_t)$$

$XLBU_t$  and  $MLBU_t$  are respectively exports and imports of bulls,

$XLST_t$  and  $MLST_t$  are respectively exports and imports of steers

$$SLXMBU_t = buslx_t \cdot (MCAH_{t-1} + MAHE_{t-1})$$

$$SLST_t = stsl_t \cdot (MCAH_{t-1} + MAHE_{t-1})$$

$$SLBU_t = SLMA_t - SLST_t$$

$$XNLMA_t = SLXMBU_t - SLMA_t + SLST_t$$

$X_t$	Bulls ( $buslx^+=1.$ )	$X_t$	Steers ( $stsl^+=0.9$ )
Constant	0.925 (8.22)	Constant	4.855 (4.13)
$tap\_bu_t$	$-0.224 \cdot 10^{-6}$ (-1.17)	$tap\_st_t$	$-0.446 \cdot 10^{-4}$ (-5.48)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-0.179 (-2.48)	$slbu_{t-1}$	$-0.165 \cdot 10^{-2}$ (-3.41)
	$R^2=0.69$ $DW=1.73$		$R^2=0.64$ $DW=0.71$

**Table 9.35. Estimation results for the bull and steer average slaughter weights**

$X_t$	Bulls ( $buasw^+=370$ )	$X_t$	Steers ( $stasw^+=360$ )
Constant	-4.015 (-1.80)	Constant	0.526 (0.25)
$buasw_{t-1}$	0.021 (3.68)	$stasw_{t-1}$	$0.806 \cdot 10^{-2}$ (1.41)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.469 (-1.80)	$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.684 (-2.26)
	$R^2=0.92$ $DW=2.06$		$R^2=0.58$ $DW=0.87$

**Table 9.36. Estimation results for the real indexes of producer prices (national currencies)**

	Calves	Adult cattle
Constant	-0.296 (-1.45)	0.070 (0.38)
Real intervention price expressed in national currency	$0.140 \cdot 10^{-2}$ (9.36)	$0.110 \cdot 10^{-2}$ (3.58)
Excess supply	$-0.563 \cdot 10^{-2}$ (-1.83)	$-0.279 \cdot 10^{-3}$ (-3.54)
$\rho$	0.38 (1.47)	0.92 (10.8)
	$R^2 = 0.92$ $DW = 1.71$	$R^2 = 0.99$ $DW = 2.32$

**ITALY**

(t-statistics are provided in parenthesis)

**Table 9.37. Estimation results for the calf model**

	Calf crop ( $cc^+=0.7$ )	Calves for slaughtering ( $csl^+=0.7$ )	Slaughtering rate ( $slr^+=0.95$ )	Calves for breeding ( $cbr^+=1.$ )	Male calves for breeding ( $mal^+=0.51$ )	Average slaughter weight ( $casw^+=150$ )
Constant	2.654 (1.70)	1.412 (12.4)	0.486 (0.61)	1.642 (1.18)	2.090 (3.99)	4.186 (6.70)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$	3.15 (1.02)		3.250 (2.06)	-5.360 (-1.94)		
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-4.311 (-2.41)		-2.184 (-2.42)	4.973 (3.15)		
$tap\_spmal_t$		$-0.394 \cdot 10^{-8}$ (-1.87)			$0.151 \cdot 10^{-7}$ (1.55)	
$\left(\frac{ipfeed}{ipgdp}\right)_{t-1}$						-1.689 (-2.97)
R <sup>2</sup>	0.60	0.37	0.35	0.59	0.18	0.41
DW	1.28	1.03	1.29	1.59	0.79	2.27

**Table 9.38. Estimation results for heifer cattle (*hehe*)**

$$HEHE_t = rdfc_t \cdot FCAH_{t-1} + hrr_t \cdot HEHE_{t-1}$$

$X_t$	$rdfc_t$ ( $rdfc^+=1$ )	$hrr_t$ ( $hrr^+=0.5$ )
Constant	-1.220 (-0.85)	0.662 (4.38)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	3.414 (2.63)	0.213 (0.95)
	$R^2 = 0.37$ $DW = 1.15$	$R^2 = 0.16$ $DW = 2.67$

**Table 9.39. Estimation results for heifer slaughtering (*slhe*)**

$$SLHE_t = (1 - rdfc_t) \cdot FCAH_{t-1} + \delta_t \cdot HEHE_{t-1} + MLHE_t$$

(all heifer imports are assumed to be slaughtered the same year, and  $XLHE_t = 0$ )

$X_t$	$\delta_t$ ( $\delta^+ = 0.5$ )
Constant	2.419 (2.83)
$tap\_scp_t$	$-0.200 \cdot 10^{-7}$ (-4.13)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-1.036 (-2.21)
$R^2 = 0.58$	
$DW = 1.83$	

**Table 9.40. Estimation results for the rates of cow replacement**

$$DAHE_t = (1 - hrr - \delta_t) \cdot HEHE_{t-1} \cdot \frac{DAHE_{t-1}}{COHE_{t-1}} + dhrr_t \cdot DAHE_{t-1}$$

$$SUHE_t = (1 - hrr - \delta_t) \cdot HEHE_{t-1} \cdot \frac{SUHE_{t-1}}{COHE_{t-1}} + shrr_t \cdot SUHE_{t-1}$$

$X_t$	dairy herd ( $dhrr_t$ ) ( $dhrr^+ = 0.9$ )	suckler herd ( $shrr_t$ ) ( $shrr^+ = 0.9$ )
Constant	2.039 (27.8)	1.171 (3.43)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$		0.732 (2.75)
$milk_t - milk_{t-1}$	$0.152 \cdot 10^{-3}$ (0.93)	
$DAHE_t - DAHE_{t-1}$		$-0.205 \cdot 10^{-2}$ (-2.00)
$R^2 = 0.12$		$R^2 = 0.42$
$DW = 0.55$		$DW = 1.65$

$$SLCO_t = (1 - dhrr_t) \cdot DAHE_{t-1} + (1 - shrr_t) \cdot SUHE_{t-1}$$

**Table 9.41. Estimation results for the heifer and cow average slaughter weights**

$X_t$	Heifers ( $hasw^+=270$ )	$X_t$	Cows ( $coasw^+=270$ )
Constant	-1.434 (-1.70)	Constant	1.441 (0.48)
$hasw_{t-1}$	0.018 (5.62)	$coasw_{t-1}$	0.013 (1.28)
		$coasw_{t-2}$	$-0.794 \cdot 10^{-2}$ (-1.43)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.571 (-5.62)	$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.312 (-2.27)
	$R^2=0.93$ $DW=1.15$		$R^2=0.46$ $DW=1.61$

**Table 9.42. Estimation results for the herd of adult males**

$$MAHE_t = vma_t \cdot (MCAH_{t-1} + MNLBU_t) + mrr_t \cdot MAHE_{t-1}$$

$$(MNLBU_t = MLBU_t - XLBU_t) \text{ (assume } XLBU_t = 0 \text{ and } XLST_t = MLST_t = 0)$$

$XLBU_t$  and  $MLBU_t$  are respectively exports and imports of bulls,

$XLST_t$  and  $MLST_t$  are respectively exports and imports of steers

$X_t$	$vma_t$ ( $vma^+=0.6$ )	$mrr_t$ ( $mrr^+=0.5$ )
Constant	0.216 (4.29)	-1.960 (-5.35)
$tap\_spma1_t$	$0.202 \cdot 10^{-8}$ (1.75)	
$tap\_spma1_t$ + $tap\_spma2_t$		$0.678 \cdot 10^{-8}$ (2.49)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$		0.529 (2.45)
	$R^2=0.20$ $DW=0.62$	$R^2=0.26$ $DW=1.15$

**Table 9.43. Estimation results for the bull slaughterings (*slbu*)**

$$SLBU_t = busl_t \cdot (MCAH_{t-1} + MAHE_{t-1} + MNLBU_t)$$

$X_t$	$busl_t$ ( $busl^+ = 0.8$ )
Constant	2.186 (39.9)
$tap\_bu_t$	$-0.263 \cdot 10^{-8}$ (-1.83)
$R^2 = 0.29$ $DW = 0.98$	

$$SLMA_t = (1 - vma_t) \cdot (MCAH_{t-1} + MNLBU_t) + (1 - mrr_t) \cdot MAHE_{t-1}$$

Slaughterings of steers :  $SLST_t = SLMA_t - SLBU_t$

**Table 9.44. Estimation results for the bull and steer average slaughter weights**

$X_t$	Bulls ( $buasw^+ = 350$ )	$X_t$	Steers ( $stasw^+ = 350$ )
Constant	-0.811 (-0.76)	Constant	0.238 (0.20)
$buasw_{t-1}$	0.011 (3.67)	$stasw_{t-1}$	$0.446 \cdot 10^{-2}$ (1.12)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.613 (-4.13)	$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.040 (-0.33)
$R^2 = 0.92$ $DW = 1.04$		$R^2 = 0.09$ $DW = 1.66$	

**Table 9.45. Estimation results for the real indexes of producer prices (national currencies)**

	Calves	Adult cattle
Constant	0.267 (1.56)	0.043 (0.19)
Real intervention price expressed in national currency	$0.123 \cdot 10^{-5}$ (4.88)	$0.137 \cdot 10^{-5}$ (2.85)
Excess supply	$-0.274 \cdot 10^{-4}$ (-0.03)	$-0.529 \cdot 10^{-3}$ (-2.56)
$\rho$	0.09 (0.26)	0.83 (13.0)
$R^2 = 0.79$ $DW = 1.97$		$R^2 = 0.98$ $DW = 2.28$

**UNITED-KINGDOM**

(t-statistics are provided in parenthesis)

**Table 9.46. Estimation results for the calf model**

	Calf crop ( $cc^+ = 0.6$ )	Calves for slaughtering ( $csl^+ = 0.15$ )	Slaughtering rate ( $slr^+ = 1.$ )	Calves for breeding ( $cbr^+ = 1$ )	Male calves for breeding ( $mal^+ = 0.51$ )	Average slaughter weight ( $casw^+ = 60$ )
Constant	1.278 (5.72)	-0.667 (-2.91)	-1.751 (-4.53)	2.047 (11.7)	3.141 (23.2)	-4.985 (-2.96)
$\left(\frac{ipca}{ipgdp}\right)_{t-1}$	0.470 (2.57)		-0.585 (-1.73)			
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$			2.889 (6.65)			
$tap\_spmal_t$		-0.195.10 <sup>-4</sup> (-4.39)		0.986.10 <sup>-5</sup> (2.81)		
$tap\_scp_t$					-0.657.10 <sup>-5</sup> (-3.49)	
$\left(\frac{ipfeed}{ipgdp}\right)_{t-1}$						
$casw_{t-1}$						0.058 (4.39)
$milk_t$						0.232.10 <sup>-3</sup> (1.93)
R <sup>2</sup>	0.22	0.45	0.73	0.34	0.34	0.60
DW	0.63	0.47	1.17	0.84	0.50	2.06

**Table 9.47. Estimation results for heifer cattle (*hehe*)**

$X_t$	$hrr_t$ ( $hrr^+ = 0.45$ )
Constant	-0.449 (-1.94)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	1.228 (6.34)
	R <sup>2</sup> = 0.63 DW = 1.93

**Table 9.48. Estimation results for heifer slaughtering (*slhe*)**

$$SLHE_t = \delta_t \cdot (HEHE_{t-1} + MLHE_t - XLHE_t)$$

$X_t$	$\delta_t$ ( $\delta^* = 0.5$ )
Constant	2.862 (8.09)
$milk_t - milk_{t-1}$	$-0.351 \cdot 10^{-3}$ (-2.22)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	-1.446 (-4.95)
$R^2 = 0.63$	
$DW = 1.91$	

**Table 9.49. Estimation results for the rates of cow replacement**

$$DAHE_t = (1 - hrr - \delta_t) \cdot HEHE_{t-1} \cdot \frac{DAHE_{t-1}}{COHE_{t-1}} + dhrr_t \cdot DAHE_{t-1}$$

$$SUHE_t = (1 - hrr - \delta_t) \cdot HEHE_{t-1} \cdot \frac{SUHE_{t-1}}{COHE_{t-1}} + shrr_t \cdot SUHE_{t-1}$$

$X_t$	dairy herd ( $dhrr_t$ ) ( $dhrr^* = 0.9$ )	suckler herd ( $shrr_t$ ) ( $shrr^* = 0.9$ )
Constant	2.245 (30.7)	2.509 (11.9)
$milk_t - milk_{t-1}$	$0.120 \cdot 10^{-3}$ (0.70)	
$DAHE_t - DAHE_{t-1}$		$-0.548 \cdot 10^{-2}$ (-2.37)
	$R^2 = 0.02$	$R^2 = 0.20$
	$DW = 2.17$	$DW = 1.37$

$$SLCO_t = (1 - dhrr_t) \cdot DAHE_{t-1} + (1 - shrr_t) \cdot SUHE_{t-1}$$

**Table 9.50. Estimation results for the heifer and cow average slaughter weights**

$X_t$	Heifers ( $hasw^+=280$ )	$X_t$	Cows ( $coasw^+=290$ )
Constant	-7.289 (-3.47)	Constant	-5.320 (-2.19)
$hasw_{t-1}$	0.041 (5.93)	$coasw_{t-1}$	0.032 (3.77)
$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.381 (-1.03)	$\left(\frac{ipfeed}{ipgdp}\right)_t$	-0.466 (-1.22)
	$R^2=0.91$ $DW=0.90$		$R^2=0.51$ $DW=2.43$

**Table 9.51. Estimation results for the herd of adult males**

$$MAHE_t = \gamma_t \cdot MCAH_{t-1} + mrr_t \cdot (MAHE_{t-1} - XNLMA_t)$$

$$XLMA_t = XLBU_t + XLST_t$$

$$MLMA_t = MLBU_t + MLST_t$$

$$(XNLMA_t = XLMA_t - MLMA_t) \text{ (assume } XLBU_t = 0 \text{ and } XLST_t = MLST_t = 0 \Rightarrow XNLMA_t = -MLBU_t)$$

$XLBU_t$  and  $MLBU_t$  are respectively exports and imports of bulls,

$XLST_t$  and  $MLST_t$  are respectively exports and imports of steers

$X_t$	$\gamma_t$ ( $\gamma^+=0.9$ )	$mrr_t$ ( $mrr^+=0.4$ )
Constant	0.346 (1.0)	0.122 (0.63)
$\left(\frac{ipct}{ipgdp}\right)_{t-1}$	0.916 (3.21)	0.366 (2.28)
	$R^2=0.46$ $DW=0.78$	$R^2=0.20$ $DW=1.63$

**Table 9.52. Estimation results for the bull slaughterings (*slst<sub>t</sub>*)**

$X_t$	$slst_t / (mcah_{t-1} + mahe_{t-1} - xnlma_t)$ ( $stsl^+ = 0.7$ )
Constant	0.784 (17.0)
$tap\_st_t$	$-0.929 \cdot 10^{-5}$ (-5.05)
	$R^2 = 0.60$ $DW = 0.79$

$$SLMA_t = (1 - vma_t) \cdot (MCAH_{t-1} + MNLBU_t) + (1 - mrr_t) \cdot MAHE_{t-1}$$

$$\Rightarrow \text{Slaughterings of bulls : } SLBU_t = SLMA_t - SLST_t$$

**Table 9.53. Estimation results for the bull and steer average slaughter weights**

$X_t$	Bulls ( $buasw^+ = 350$ )	$X_t$	Steers ( $stasw^+ = 350$ )
Constant	-2.778 (-3.20)	Constant	-5.602 (-14.2)
$buasw_{t-1}$	0.016 (5.80)	$stasw_{t-1}$	0.025 (19.1)
$\left( \frac{ipfeed}{ipgdp} \right)_t$	-0.324 (-2.81)		
	$R^2 = 0.69$ $DW = 1.98$		$R^2 = 0.94$ $DW = 1.24$

**Table 9.54. Estimation results for the real indexes of producer prices (national currencies)**

	Calves	Adult cattle
Constant	-0.015 (-0.04)	-0.369 (-3.07)
Real intervention price expressed in national currency	$0.388 \cdot 10^{-2}$ (2.84)	$0.520 \cdot 10^{-2}$ (12.8)
Excess supply	-0.013 (-0.40)	$-0.293 \cdot 10^{-3}$ (-1.85)
$\rho$	0.44 (2.28)	0.50 (3.78)
	$R^2 = 0.51$ $DW = 1.28$	$R^2 = 0.96$ $DW = 2.19$

## **10 - A SOFTWARE FOR DEPICTING THE REGIONAL MARKET OF AN APPELLATION OF ORIGIN**

**The Common Market Organisation for wine: A shift from price support policy to quality support policy**

**What are the rights to supply regulations for subsidiary organisations?**

Eric Giraud-Héraud, Jacques Laye and Hervé Tanguy

Partner 2: INRA-ESR, Grignon

### **10.1. Introduction**

With an average of 60% of the production and consumption, 70% of imports and 83% of exports for 45% of cultivated land surface, the European Union dominates the world wine-producing sector. Its ultimate production surpasses 12 billion Euro, 2 billion of which come from markets outside of the European Community. However, since 1975-1976, the cultivated surface area of vineyards in Europe has been constantly decreasing due to European measures taken by the Common Market Organisation (CMO) limiting new plantations and giving bonuses for stopping production permanently. The surface area has thus slipped from 4.5 million hectares to 3.4 million between 1976 and 1996 and production from 210 million hl to 155 million hl.

The CMO wine-producing industry is, without a doubt, the most complex regulation of any of the common agricultural policy to the extent that it not only covers classical questions regarding each CMO (prices, intervention, exchanges etc.), but also other more specific questions pertaining to the wine sector (oenology practices, and details relating to production and marketing). The new regulation (rule (CE) n° 1493/1999) proposes freezing plantation rights with a distribution of aid towards high added value operations (a policy favouring quality). Important directives have been taken concerning market techniques (rule n° 1622/2000) and the explicit integration of the VQPRD into the CMO (rule n°1607/200). From the point of view of market techniques we observed a relative simplification of intervention methods on the table wine market with the suppression of the orientation price and the reduction of the distillation system ( particularly by the elimination of required distillation).

However, on the economic level, the point which seems to us the most determining in the end is that the new CMO in Title IV enlarges the role of producer organisations and sectoral organisations. The objective of the organisations whose decisions most often become compulsory, now no longer limits

itself to a policy of product advertising and sharing Research and Development. It concerns among other things intervening more and more explicitly on the business level through a regulation of the supply in order to maintain a qualitative level of the products which correspond mostly to an appellation of origin. Article 41 of Title IV of the CMO makes the provision that the producer organisations and sectoral organisations can define the marketing rules dealing with the regulation of supply when they are first put on the market (the stocking and staggered distribution of the products) insofar as there would not be an excessive blockage at harvest or price fixing even as an indication.

Nevertheless, the fact that the decisions of the subsidiary organisations have been made obligatory requires a constant reminder from the point of view of the risks involved with a compulsory co-ordination of marketable quantities. Indeed, this interference with free commerce could appear dangerous from a public interest point of view and it is necessary to examine whether the measures taken conform to EC rulings which are based on the interests of producers and marketers as well as those of consumers. Thus, in a series of cases dealing with mandatory financing of French inter-professionals, the European Court of Justice considered the said financing compatible with European law as long as their activity is itself compatible with the right of competition.

Recent studies (Giraud-Héraud et al, 1998) show theoretically the formal connection which exists between the appellations of origin and the regulation of supply on a decentralised level. They make the consequences generated for consumers (arbitration of quality-price) clear and give the economic arguments which justify a system of appellation of origin based on an entry barrier for producers which does not come from the appellation region.

On the empirical level, we set forth in the study a mathematical formalisation which permits quantifying the gains and losses related to the respect of a co-ordination mechanism for the launching of products of wine production. Our study gives an evaluation of marketed quantities as well as an evaluation of the average quality of the products of a region of appellation of origin and within the framework of uncertain annual production. An economic assessment provides a quantified appraisal of the role played by sectoral organisations which act as a «local monopoly» (hence the higher prices for the consumer due to a scarcity of goods) in order to improve the average quality of wines on the market.

Implementing computer software enables us to quantify the effects on actual data of such a policy on the producers' surplus and on consumers. The essential information for carrying out this economic assessment is the specific characteristics of a vineyard at the supply level (production capacity in relation to plantation rights, storing capacity and putting the production in reserve, etc.) and at the demand level (size of the market and the possibility of valorisation with consumers) by explicitly considering the structural characteristics connected to the variations of quality and quantity of the

wine-growing region being considered. Moreover the simulations take into account the effect of competition from other wines from different regions than the wine-growing region under study, but which can serve as replacement wines in the eyes of the consumer.

In section 2, we present the rulings which deal with the sectoral organisations. Section 3 describes the principles of supply regulations of sectoral organisations and deals with modelling as such. Section 4 describes simulated scenarios and synthesised obtained simulation results. Section 5 concludes.

## **10.2. Regulation and quality reserve**

Within the framework of Title IV, the new CMO acknowledges the sectoral organisations. In particular, Article 42 1.(c ) recognises as inter-professional organisations any individual who undertakes, in one or more regions of the EU, several of the following actions, in recognition of consumer interests:

*(ii) contribution to a better co-ordination of the launching of products especially by research and market studies;*

*(iv) intensification of the importance of production potentia;*

*(v) information and research necessary for the orientation of production towards products which are more adapted to market requirements and to the tastes and expectations of consumers, especially in matters of quality and environmental protection;*

*(vii) Adjustment of methods and instruments to improve product quality at all stages of production, of wine processing and marketing.*

However, in accordance with Article 42, the Member States recognise the organisations on condition:

*2.(e) that they do not affect the efficient operation of the market organisation and do not have in their activities those mentioned in Article 43 paragraph 1.*

And in particular withdraw recognition if:

*4. (c ) (ii) the inter-professional organisation infringes on one or another of the prohibitions stated in Article 43, paragraph 1, without prejudice of the other sanctions incurred elsewhere in application or national legislation.*

Article 43.1 is a derogation of Article 85 of the Treaty of Rome for actions taken by organisations which do not have for a purpose:

*(a) to allow whatever form of partitioning of the market within the EU;*

*(b) to create discrimination or to eliminate competition for a substantial part of the products in question;*

*(c) To create unnecessary distortions in competition to reach the objectives of common agricultural policy followed by inter-professional action.*

If we examine these considerations any regulatory measure should be the object of a study to determine its impact from the point of view of competition policy.

In this context the establishment of a qualitative reserve by subsidiary organisations constitutes the instrument for regulating the preferential offer which allows a decentralised management of the supply. The need, which is felt more and more, to provide too much choice in marketed quality wines each year is concomitant with a need for regulation of marketed quantities and therefore of an artificial rise in prices for consumers. On the strictly economic level, it might be necessary to "gauge" the quantity to be marketed each year in order to best adapt the offer to the demand of consumers. Concerning non-vintage wines, the creation of a qualitative reserve can go as far as allowing the collection of several vintage wines to optimise the average qualitative level of marketed wines.

In that case, the creation of a qualitative reserve in a production pool might not meet conditions (a), (b) and (c), cited above, even if most of the major European vineyards today plan to improve the possibilities of strategic supply control with this system. The oldest examples we can give for the management of a qualitative reserve are certainly those for Porto wine in Portugal and Champagne in France, for which a system of "freezing and unfreezing" established by the "Conseil Interprofessionnel des vins de Champagne" has existed for a long time. This example will serve as the basic reference in our model.

### **10.3. A simulation model**

We simulate the commercialisation of a wine-growing region by supposing that we find ourselves in a situation where a sectoral organisation imposes its strategic decisions on the other actors in the sector with the objective of optimising the calculated profit. We suppose nevertheless, that there is competition on the market from various other wines in terms of quality. Customer demand is concerned with the price of the product, but also with its quality, taken under its economic aspect as a parameter positively affecting the willingness of the consumer to pay. Considering the competitive environment in which the vineyard finds itself, the quality of the competing wines on the market is assumed to be the best response to the average quantity yield for the region under consideration.

The exogenous variables which are considered for characterising the potential supply of the vineyard are as follows:

- the size of the vineyard in relation to obtained planting rights;
- the agronomic output which, multiplied by the vineyard size corresponds to the actual quantity produced;
- the objective quality of the grapes here represented by the degree of alcohol content in relation to the acidity of the variety of vine which is used;
- a maximum production (authorised production of appellation or buffer depending on the text), beyond which the quantities must be done away with. Cultural practices are also limited insofar as they only relay the means of distribution of the reserves on the quantity and the quality;
- an available wine production corresponding to the volume of grapes that each wine grower is actually authorised to make into wine, multiplied by the percentage of wine obtained from processed grapes;
- a maximum reserve guaranteeing that an excessively high proportion of previous yields does not diminish the quality of the reserve;
- the quantity and the quality of wine placed on the market by the competing vineyard;
- the additional cost of production caused by producing high quality wine;
- a constant multiplier of the cost of the divergence from the targeted average quality.

Disregarding climate conditions, agronomic yields depend on numerous factors: the variety of grapes, the age of the vineyard; its location, the planting methods, the cultivation practices, etc. Generally speaking, beyond a certain point, high production is obtained to the detriment of wine quality. For the exogenous fixed conditions in particular of the vineyard (i.e., in a *ceteris paribus* reasoning), there is an inverse relation between control of production and official natural alcohol content which measures the quality of the grapes. Production therefore has a double outcome: quantitative and qualitative. However, when all these factors are established and the harvest is the fruit of a favourable climate, quality most often accompanies quantity as observed *ex-post*. This phenomenon is even more noticeable when we are dealing with a northern vineyard. In this case, the favourable conditions for the growth of the vines are also those which permit the good ripening of the grapes.

### ***10.3.1. The reference situation: Free marketing***

We consider the situation where the sectoral organisation is not authorised to dictate the instructions for the wine reserves of the wine-growers. In this situation the dominant individual strategy consists in putting all available quantities on the market. Indeed, the individual wine reserves has, as it were, no effect on the average quality of the wine that is noticeable on the market to the consumer and no affect

on the sales price. In the event that it is impossible to have a co-ordination furnished by an organisation, individual decisions for stocking would end in the loss of profit for the wine grower.

### 10.3.2. Regulation of supply

We examine a simplified regulation process where the decision of the marketed quantity constitutes the only strategic variable for the organisation. This variable represents the only possible reaction to the quantity and quality of the grapes in regard to the reserves.

The agronomic production for the year  $i$  defines a yield  $\alpha_i$  of grapes of quality  $k_i$  which coincides with the quantities present in the reserve obtained from the preceding campaign  $X_{i-1}$ . Thus knowing the parameters  $\alpha_i$  and  $k_i$  which he is informed of at the beginning of the campaign, the wine grower can know the situation of his stock in quantity  $X_i$  and in quality  $k_i$ . It is in relation to this situation that the wine grower will take his decision for drawing  $u_i$  which after wine making will be sold to traders. Thus:

$$\begin{array}{c} \alpha_i, k_i \rightarrow X_i, k_i \rightarrow u_i \\ \downarrow \\ \alpha_{i+1}, k_{i+1} \rightarrow X_{i+1}, k_{i+1} \rightarrow u_{i+1} \\ \downarrow \end{array}$$

It concerns a problem of decision making in the presence of incertitude. The quantity put in the reserve depends solely on the situation of the preceding reserve, on the decision for the preceding drawing and on the quantity harvested during the campaign. The situation of the reserve therefore only depends on the past via the preceding campaign:

$$X_{i+1} = X_i - u_i + \alpha_{i+1}$$

Under these conditions, the quality of the reserve, the average being weighed by the quantities of the qualities of the preceding reserve and of the current harvest, depends only on the preceding situation:

$$k_{i+1} = \frac{k_i(X_i - u_i) + k_{i+1}\alpha_{i+1}}{X_i - u_i + \alpha_{i+1}}$$

The issue of the situations of the reserve of the form  $((X_n, K_n)_{n \in N})$  constitutes therefore a markovian process.

The problem of optimal control which confronts the wine grower at date  $i = 0$  is the following: knowing the laws that random variables  $\tilde{\alpha}$  and  $k$  follow, what is the optimal strategy which will allow the maximum hope of in between time profit?

The first objective of the model is to optimise the stock decisions in the qualitative reserve and to distribute on the market, in relation to the situation of the stock, that is to say, the quantity from the qualitative reserve obtained from the preceding campaign mixed with the new harvest. The wine grower maximises his between time profit:

$$\Pi = \sum_{i=0}^{+\infty} \frac{1}{(1+\lambda)^{n+1}} (p_1 - c_1) q_1 - q_i \varepsilon(\max(k_1 - k_{ref}, 0))^2$$

The expression  $\varepsilon(\max(k_1 - k_{ref}, 0))^2$  corresponds to a unitary variance cost in relation to the quality reference of the vineyard. If the quality put on the market is superior to  $k_{ref}$  this cost is null. If, on the contrary, the vineyard was only able to obtain an inferior quality we consider that it can withstand the cost of recapturing the market.

The second objective is, knowing the optimal stock decisions (complementary to marketing decisions), to compare this situation to that of the free marketing for which the individual strategy of each wine grower consists in putting the totality of available quantities on the market each year.

### 10.3.3. The demand side

Concerning the demand model on the final market, we consider the heterogeneous tastes of the consumers for the quality of the supplied goods. Strictly speaking, each consumer is characterised by a taste  $\theta$  for quality, uniformly distributed on  $[0, \bar{\theta}]$  where  $\bar{\theta}$  represents the heterogeneity of the consumers' tastes. We denote  $f(\theta) = \frac{1}{\bar{\theta}} X_{[0, \bar{\theta}]}$  the density of distribution of the consumers regarding tastes.

The consumption of a unit of good of quality  $k$  at price  $p$  leads to a utility  $\theta k$ , the surplus of a consumer of type  $\theta$  being given as:

$$S(\theta, k, p) = \theta k - p$$

The consumer  $\theta$  buys the good only if it procures him a positive surplus. If we consider two types of wine sold on the market, one standard quality wine noted as  $k_0$  (considered here as a substitute for the consumer) and a higher quality wine denoted  $k_1$  only the  $[\frac{p_0}{k_0}, \bar{\theta}]$  segment of the market is covered.

The consumers buying standard  $k_0$  quality are dispersed over the interval  $[\frac{p_0}{k_0}, \tilde{\theta}]$ , those who prefer the higher quality  $k_1$  on  $[\tilde{\theta}, \bar{\theta}]$ , where  $\tilde{\theta}$  corresponds to a consumer indifferent between the two qualities offered ( $\tilde{\theta} = \frac{p_1 - p_0}{k_1 - k_0}$ ).

We deduce the demand for each of the two products in relation to the size of the market  $M$  specifying the number of consumers or more precisely here the maximum demand for the goods under consideration, expressed in millions of bottles.

$$q_0 = M \int_{\frac{p_0}{k_0}}^{\tilde{\theta}} f(\theta) d\theta = \frac{M}{\theta} (\tilde{\theta} - \frac{p_0}{k_0})$$

$$q_1 = M \int_{\tilde{\theta}}^{\bar{\theta}} f(\theta) d\theta = \frac{M}{\theta} (\bar{\theta} - \tilde{\theta})$$

By inverting this system we obtain the prices of the two types of wine:

$$p_0 = \frac{\bar{\theta} k_0}{M} (M - q_0 - q_1)$$

$$p_1 = \bar{\theta} k_1 - \frac{\bar{\theta}}{M} (k_0 q_0 + k_1 q_1)$$

If we consider the market price as being directly determined by the quality marketed, the overall consumer surplus is measured by:

$$W_c = M \int_{\frac{p_0}{k_0}}^{\bar{\theta}} S(\theta, k, p) f(\theta) d\theta = \frac{\bar{\theta}^2}{2M} (k_1 q_1^2 + k_0 q_0^2 + 2k_0 q_0 q_1)$$

### 10.3.4. Optimal decision on drawing

Let  $E$  be the whole situation of the reserve in quantity and quality:  $(X_i, k_i) \in E$

With  $X \in F = \{0, \dots, X_{max}\}$  and  $k \in \{0, \dots, k_{max}\}$  the number of possible situations is  $|E| = (X_{max} + 1)(K_{max} + 1)$ .

Let  $F$  be the control area.  $u \in F$  corresponds to the quantity drawn so that it can be made into wine.

The long term profit (with  $\lambda > 0$  the discount rate) to be maximised is written as:

$$\text{Arg max } E \left\{ \sum_{n=0}^{+\infty} \frac{1}{(1+\lambda)^{n+1}} \Pi_n(X_n, k_n, u_n) \mid X_0 = x, k_0 = h \right\}$$

$$\text{Arg min } E \left\{ \sum_{n=0}^{+\infty} \frac{1}{(1+\lambda)^{n+1}} (C - \Pi_n(X_n, k_n, u_n)) \mid X_0 = x, k_0 = h \right\}$$

where  $s$  is a strategy, that is, an application of  $E$  within  $F$ , which in each situation  $(x, h)$  includes a control  $u$ . We note  $C$  by raising the profits.

This problem of dynamic planning is resolved by the Howard algorithm, which rests on the following result:

**Proposition 1.** For  $(x, h) \in E$ , in noting  $u_{x,h}$  the unique solution of:

$$\min_{u \in F} \{ (M^u - (1+\lambda)Id) v_{x,h} + (C - \Pi_0(x, h, u)) \} = 0$$

So:

$$v_{x,h} = \min_s E \left\{ \sum_{n=0}^{+\infty} \frac{1}{(1+\lambda)^{n+1}} (C - \Pi_n(X_n, k_n, u_n)) \mid X_0 = x, k_0 = h \right\}$$

The principle of the Howard algorithm is to set up any strategy  $s_0$ , to include a vector  $w_0$ , solution of:

$$(M^u - (1+\lambda)Id)w_0 + (C - \Pi_0(x, h, u)) = 0$$

For the controls  $u$  corresponding to the strategy  $s_0$ .

The following stage of the algorithm is to include with  $w_0$  a new strategy:

$$s_I : x \in E \rightarrow u \in \arg \min_{u \in F} \{((M^u - (1 + \lambda)Id)w_0)_{x,h} + (C - \prod_0(x,h,u))\}$$

We then return to the first stage. We show that this iteration converges towards a unique optimal strategy  $s^*$ .

### 10.3.5. The developed software

Drawn on the previous modelling principles, the developed software allows, thanks to the Howard algorithm, to obtain the optimal strategy in relation to the reserves, for any vineyard. It requires as inputs:

- a maximum reserve  $X_{\max}$  and a precision  $\Delta X$  in such a way so that  $X \in \{0, \Delta X, 2\Delta X, \dots, X_{\max}\}$ ;
- an integer  $\Delta k$  corresponding to the number of times that we divide the differences in the quality of grapes  $[\frac{1}{2}, 2]$ ;
- the mean ( $\bar{\alpha}$ ) and the standard deviation ( $\sigma_\alpha$ ) of the quality index for grapes;
- the size of the market  $M$ ;
- the heterogeneity of consumers' tastes  $\bar{\theta}$ .
- the quantity  $q_0$  and the quality  $k_0$  of the competing vineyard;
- the additional costs ( $c_1$ ) of the vineyard under study;
- a constant multiplier  $\varepsilon$  of the cost difference in relation to the reference quality.
- the rate of current value  $\lambda > 0$ .

#### 10.3.5.1. The law of agronomic performances

The random process studied is a Markov chain. Since we only consider a finished number of situations, it is necessary to transform continuous laws into discrete laws. Let's assume that the agronomic performances follow a normal law such as:

$$f_{\alpha}(a) = \frac{1}{\sqrt{2\pi}\sigma_{\alpha}} e^{-\frac{(a-\bar{a})^2}{2\sigma_{\alpha}^2}}$$

We define for each  $\alpha \in Def(\alpha) = \{0, \dots, X_{\max}\}$

$$P[\alpha = \alpha_0] = \frac{f_{\alpha}(\alpha_0)}{\sum_{\alpha_i \in Def} f_{\alpha}(\alpha_i)}$$

We check thoroughly that  $\sum_{\alpha_i \in Def} P[\alpha = \alpha_i] = 1$

### 10.3.5.2. The law of grape quality

Since the quality  $k$  of the reserve is a result of a measurement, it does not belong to a discrete unity of qualities. It is therefore necessary to consider the probability for  $k$  to belong to an interval concerned with planned situations.

The given  $\Delta k$  defines a certain number of quality indexes. We indicate  $Def(k)$  all of these reference qualities and  $\delta$  the actual step between these qualities. The result is a division of the interval  $[\frac{1}{2}; 2]$ . Let's assume that:

$$\forall k_0 \in Def(k), F(k_0) = \frac{f_k(k_0)}{\sum_{k_i \in Def(k)} f_k(k_i)}$$

For any  $k \in ]\frac{1}{2}, 2[$  we assume:

$$P[k \in [k_0 - \frac{\delta}{2}, k_0 + \frac{\delta}{2}]]_{k_0 \in Def(k)} = \frac{F(k_0)}{\delta}$$

$$P[k \in [\frac{1}{2}, \frac{1}{2} + \frac{\delta}{2}]] = \frac{F(1/2)}{\delta/2}$$

$$P[k \in [2 - \frac{\delta}{2}, 2]] = \frac{F(2)}{\delta/2}$$

Therefore, we will consider a uniform law for each interval of the division  $[\frac{1}{2}, 2]$ . We also verify that it indeed corresponds to a law of probability.

### 10.3.5.3. The transition matrix

We consider  $(x, h) \rightarrow (y, l)$  the transition of the situation  $(x, h)$  to the situation  $(y, l)$ . We associate an element of the precept base  $\mathfrak{R}^{|E|}$ . As such  $(x, h)$  corresponds to element  $e_{xh}$ . The transition matrix for a fixed control  $u \in F$  is a square matrix of size  $|E|$ . Thus we will have to consider  $|F|$  transition matrixes. The coefficient corresponding to column  $c = e_{yl}$  and to line  $l = e_{xh}$  of  $M^u$  is:

$$((M^u))_{l,c} = P[(X_{i+1}, k_{i+1}) = (y, l) \mid (X_i, k_i) = (x, h) \mid$$

An order is acceptable only if it does not exceed the available level of the reserve. Thus for the lines of the matrix  $M^u$  such as  $u \geq X$ , we set the order at  $u = X$ . In other words, the whole reserve is drawn. The following situation will only depend therefore on random variables  $\tilde{\alpha}$  and  $\tilde{k}$  (harvested quantity and grape quality). We obtain:

$$P[(X_{i+1}, k_{i+1}) = (y, l) \mid (X_i, k_i) = (s, h)] = P[\alpha = y].P[k = l]$$

In this way we form the  $(u + 1)$ , first lines of the matrix.

If  $u < X$ , we have the formula:

$$\begin{aligned} & P[X_{i+1} = y, k_{i+1} \in [l - \frac{\delta}{2}, l + \frac{\delta}{2}] \mid X_i = x, k_i = h] \\ &= P[\alpha_{i+1} = y - x + u] P[k_{i+1} \in [\frac{(l - \frac{\delta}{2})y - h(x - u)}{y - x + u}, \frac{(l + \frac{\delta}{2})y - h(x - u)}{y - x + u}]] \end{aligned}$$

Concerning the side effects, we consider that any quantity which leads to a situation which surpasses the maximum reserve must be eliminated. The probability of an outcome of a situation which achieves the maximum of the reserve is therefore the sum of the probabilities of creation of the situations of which the quantity surpasses this maximum reserve.

Finally, we will suppose that for the harvests which lead to a surplus of the maximum reserve, a substitution of the quantities of the reserve by the quantities of the harvest is possible.

### 10.3.5.4. The basic structure of the software

Starting from a reference situation, we change different parameters in order to create new situations. For each one of them a series of agricultural performances and grape quality are randomly given so as to know the average results reached by freezing.

For each situation we examine three values for the multiplier constant from the margin cost to the reference quality.

Using the Howard algorithm on each of the 15 scenarios, we obtain the control matrixes: for a quality and a quantity in the reserve, an optimal drawing directive corresponds.

Once implemented in the control panel, the data and the control matrix are used over a period of 20 years in relation to the operations which are allowed: freezing or competition.

In order to obtain statistical results, 20 series produce agronomic output and grape qualities according to the appropriate rules.

For each of the 15 scenarios we supply:

- the directives laid down by the software;
- the recapitulations of the applications;
- an evaluation of the results year by year, with the means, sums and standard deviations for the period and percentage variations obtained through the freezing mechanism;
- graphs of the different variables to be analysed;
- a recapitulation of the results obtained after 10 experiments with the same data as well as their averages.

The outlines studied are not exhaustive, but represent the type of analysis which can be undertaken thanks to the tool which has been developed.

#### **10.4. Simulation of a Northern vineyard**

##### ***10.4.1. The reference situation***

We consider the following as a reference situation which is characteristic of a Northern region:

- as with the example of Champagne, the agronomic production follows a normal central law with a 270 million bottles mean and a 100 million bottles standard deviation;
- the average quality of the wine ( $k_{vin} = 50$ ), reached by normalisation of the heterogeneity of the consumers ( $\bar{\theta} = 1$ ) is affected by a vintage factor corresponding to the quality of the grapes for the year. This grape quality is centred on 1 and has a standard deviation of 0.2;
- the size of the vineyard is 30 000 hectares;

- the maximum authorised production established by INAO is 13000 kg/ha, which corresponds to 330 million bottles.
- the maximum reserve ( $X_{\max}$ ) is 445 million bottles<sup>139</sup>;
- the size of the market is estimated at 1000 bottles;
- we assume that the additional cost of production is nil  $c_1 = 0$ .
- we will vary the constant  $\varepsilon$ .
- the discount rate is 5% ( $\lambda = 0,05$ ).

Based on this reference situation we will change different parameters in order to create new situations. For each of them we will generate a random series of agronomic performances and grape quality in order to know the average results obtained by freezing. Indeed, the improvement of results by the freezing method depends, of course, on the series of agronomic performances and the quality of grapes which determine a given situation of the qualitative reserve.

An unfavourable configuration is one where the reserves succeed each other in such a way that the establishment of a qualitative reserve becomes difficult. It is particularly the case when only one good harvest is isolated among bad harvests, almost completely drawn from the following campaign, it does not allow the acceptable phasing of subsequent reserves. However, we will notice that in this situation, the drawing strategy adopted by the algorithm leans towards competitive strategy.

#### ***10.4.2. The simulated scenarios***

Four scenarios are simulated:

- The "**double reserve**" scenario differs from the reference situation by the storage capacity, which is doubled (i.e., 890 million bottles).
- The "**meridian**" scenario corresponds to the case of a vineyard which would have the same characteristics as the reference vineyard except the standard deviation of the quantity harvested. Indeed, the more stable climate of meridian vineyards leads to less random harvests. Here, the standard deviation is divided by two.

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<sup>139</sup> A maximum capacity of the qualitative reserve avoids having too many old vintage wines which would diminish the quality of the reserve. We will accept here a reserve of a maximum of half a harvest after drawing (in millions of bottles)  $stock_{\max} = 330 + 115 = 445$ .

- The "**southern**" scenario differs from the previous "meridian" scenario by the standard deviation of the grape quality, which is divided by two.
- The "**excess costs**" scenario allows us to examine the impact on the reference vineyard of a 5 Francs additional unitary cost of quality production.

For each of these scenarios we consider three different values of the multiplier constant from the variable cost to the reference quality.

By using the Howard algorithm on each of these 15 scenarios, we obtain control matrixes: for a quality and a quantity in the reserve there is a corresponding control for maximum drawing.

Once established in the control panel, the information and the control matrix are valid over a period of 20 years according to the operations allowed: freezing or competition.

In order to obtain statistical results, 20 series, which follow appropriate laws, produce agronomic performances and grape qualities.

#### ***10.4.3. Simulation results***

All simulation results are presented and discussed in details in Laye (2000). In general, results may be synthesised in five points:

- i) When it is possible to regulate the quantity supplied on the market through the reserve management, supply decreases leading to an increase in the price of wine (for example, the "double reserve" scenario leads to an average +7.49% increase in the price of wine with respect to the reference scenario).
- ii) This price effect is, partly or totally, compensated by an increase in the average quality offered to consumers (the quality effect being greater as the bottling increases). Nevertheless, the most remarkable phenomenon is the smoothing of the quality in the course of time. Indeed, the decrease in the standard deviation of quality offered to consumers reaches 45.5% in the "double reserve" scenario with respect to the reference situation.
- iii) As a result, the surplus of consumers does not decrease significantly (-1.5%) due to the regulation of supply. We can, however, note that here the consumer is not aware very much of the smoothing of the quality, which influences this counter-performance.
- iv) Finally, the possibility of supply regulation through the reserve management improves the strategic marketing capacity of producers. This possibility has a sizeable effect on the smoothing of the average quality of wines offered to consumers. Hence, the producers' and

the consumers' surplus may be improved in certain cases by the subsidiary organisation relative to the competitive situation.

- v) Lastly, one may notice that obtained results are rather sensitive to the assumed characteristics of the considered vineyard, particularly those relating to the variability of both harvested production and quality of vintage wines.

### **10.5. Conclusion: CMO-WTO compatibility**

One of the main features of the wine-growing and wine making Common Market Organisation, established from the year 1999, is that it marks the replacement of a price support policy by a quality support policy. Such a shift in policy allows the maintenance of the EU wine CMO budget expenditures (which accounts for less than 3% of the FEOGA guaranteed budget.<sup>140</sup> For these reasons it seems unlikely that the quality support policy provided by the new wine CMO be challenged during the ongoing multilateral WTO negotiations, even more so since the control of plantation rights can be perceived as a distortion of competition acting in favour of third countries.<sup>141</sup>

Under these conditions, the biggest stumbling block between the orientations of the new CMO and the negotiations lead by the WTO remains undoubtedly that of standardisation of the products with two types of design in the background: on the one side, a general standardisation of the codex alimentarius and, on the other side, a specific standardisation in the sector represented by the directives of the Office International de la Vigne et du Vin (OIV). In the first case, we are only concerned about human health to define the wine product. In the second case, we are concerned about the agricultural origin of the product and we consider wine as the product procured from the natural fermentation of the grape (consequently, corrective oenological practices are necessarily limited). Thus, may we consider that the CMO belongs rather to the second category, in asserting the VQPRD system.

The agreement on the aspects of intellectual property rights opens the way to a multilateral protection of geographic indications. However, if these agreements provide for setting up a register of geographic indications in the wine and spirits sector, a wide divergence of interpretations exists as to the use of this register. The European Union considers that it should be a priority instrument exercised on every member state of the WTO, where American and especially Japanese positions aim at establishing a simple informative list.

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<sup>140</sup> As a comparison, grains account for 19% of the FEOGA guaranteed budget.

<sup>141</sup> However a great number of trade barriers still exist (customs rights, importation quotas, discriminatory excise taxes, importation monopolies, etc.), which could be put on the table. In this study, we do not deal with these aspects mainly because they relate to inter-European rather than multilateral trade concerns and because they do not directly relate to the new wine CMO (see Arnaud et al., 2001).

A contrario, the WTO within the framework of the health and plant health agreements recognises the suitability of the codex alimentarius who are exclusively concerned with matters of health and therefore more interested in the decrease of alcohol content.<sup>142</sup> Thus, the present directions of the WTO are very far removed from the directives of the OIV (see Hanin et al., 2000) which are based on a recognition of regions and on the restraints of production (determination of the production zone and production requirements) characteristic of appellations of origin. In the same way, these directions are likely to establish new arrangements for the wine production of the CMO, which could be inconsistent with international legislation.

Furthermore, at the regional and local level wine growing is a determining factor in agricultural and economic operations and can account for over 30% of agricultural end production (50% in the case of Languedoc-Roussillon). There are, in addition, very different realities from one member state to another, not only concerning the size of the vineyard, but also the degree of specialisation of the operation and of the type of wines produced. These factors require the decentralisation of the regulation procedures at the producer organisations and subsidiary organisations level, towards which the new CMO is heading. For example, in France, most of the AOC regions benefit from an inter-professional organisation, officially recognised by the state, which is associated with appellation syndicates. These organisations bring together the different professional structures representing a branch in view of assuring the management and development of wine production with the necessary financial means. On the economic level these organisations; although limited by AOC regulations, managed by the INAO (concerning supervision of supply, via limiting the regions and overseeing the performance) today constitute the heart of the system with a better and better supervision of the quantities placed on the market (this procedure is also used in a good number of Italian, Spanish and Portuguese vineyards).

The non-recognition of appellations of origin at the international level would challenge the role of the subsidiary organisations in the long run, which really means reconsidering the orientation of the wine CMO. It is also necessary to confirm or to indicate the weakness of the basis, on the economic level, of this European orientation.

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<sup>142</sup> A description of the stakes of multilateral negotiations for the wine growing sector can be found in Dubos (2000): "L'organisation mondiale du commerce prépare l'Europe viticole de demain", Cahiers de l'Observatoire des Conjonctures Viticoles Européen, n°1.



## **11 - ASSESSMENT OF THE IMPACT OF FOOD SAFETY AND QUALITY STANDARDS ON EU-US TRADE IN AGRICULTURAL AND FOOD PRODUCTS**

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### **11.1. Introduction**

The objective of this part of the project (i.e., task 3) was to assess the impact of current food quality and safety standards on EU-US trade in agricultural and food products. The analysis reported in this chapter focuses more specifically on the impact of US food quality and safety standards on EU agricultural and food exports to the US.

Section 2 provides the background of the analysis and a thorough review of literature on technical measures. This literature review successively addresses the questions of the classification of technical measures, their effects on trade and the available methods for measuring these trade effects. Finally, existing studies that have attempted to measure the effects of technical measures in the context of trade in agricultural and food products are reviewed.

The literature review suggests that there are four basic approaches commonly used to evaluate the trade impact of technical measures: frequency/inventory-based measures; price-comparison measures (or tariff equivalent estimates); compliance-cost measures; quantity-type measures. Thus, the impact of US standards on EU agricultural and food exports to the US is analysed combining the first three approaches. Sections 3, 4 and 5 each propose an assessment of the impact of US standards on EU exports to the US according to, respectively, the frequency/inventory approach, the price-comparison approach and the compliance-cost approach. In addition, complementary to previous assessments, section 6 provides an analysis of US detentions of EU agricultural and food exports.

Finally, section 7 concludes and draws some policy recommendations.

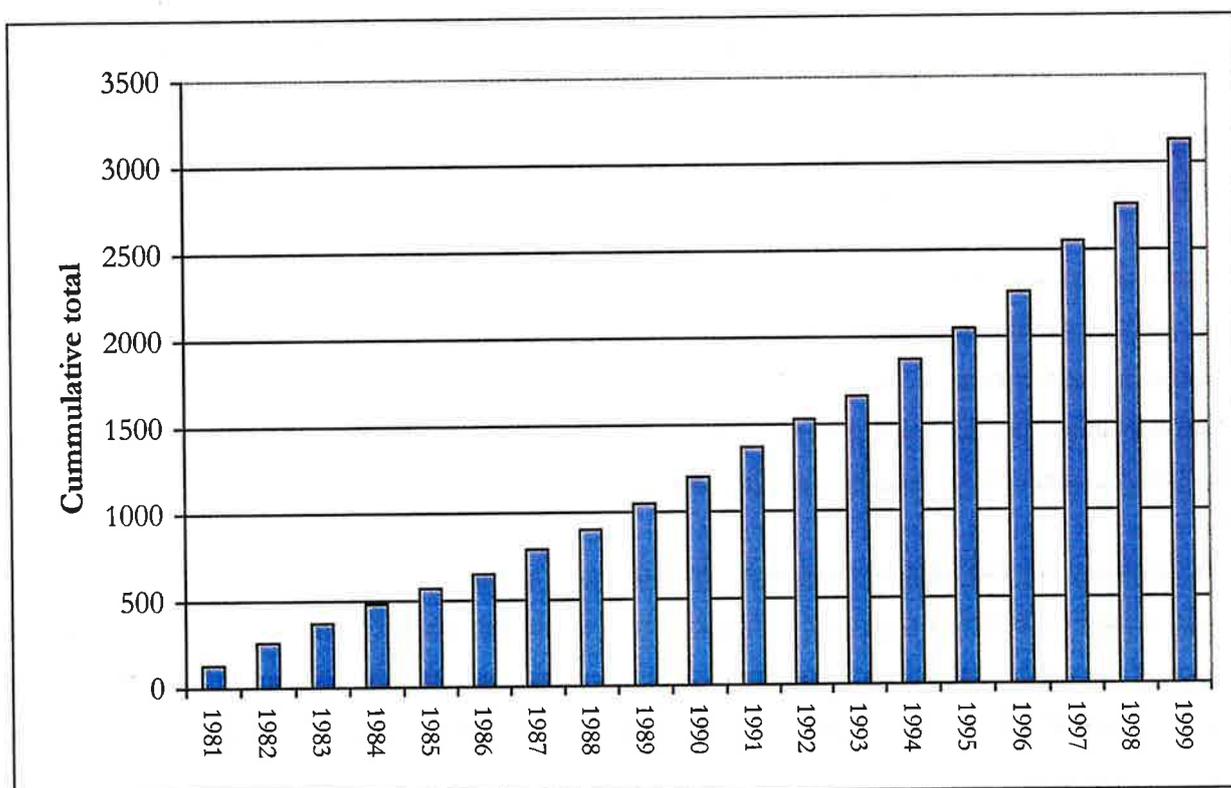
### **11.2. Technical barriers to trade**

#### ***11.2.1. Background***

In recent years there has been heightened interest in the impact of technical barriers to trade on exports of agricultural and food products. Technical barriers to trade are measures that restrict imports of products that fail to meet safety, quality or environmental standards. Concern about the impact of

technical barriers to trade has mirrored the global proliferation of these measures over time, particularly in developed countries. This is evident from the number of notifications of technical measures to GATT/WTO over the period 1981-00 (Figure 11.1). Furthermore, it is more widely recognised that technical measures can act, either explicitly or implicitly, as barriers to trade in a similar manner to tariffs and quantitative restrictions (Laird and Yeat, 1990; Vogel, 1995; Sykes, 1995).

**Figure 11.1. Notifications of technical measures to GATT/WTO, 1981-99**



Source: Henson et al. (2000)

Considerable efforts have been made to develop methods through which the extent of trade covered by non-tariff measures and/or their frequency of application can be quantified (Laird and Yeats, 1990; Laird, 1997). Such efforts are, however, fraught with difficulties because of the number and range of measures applied and the rate at which incidence changes over time. Furthermore, data is required at a high level of disaggregation as many non-tariff measures, and in particular technical measures such as food safety and quality requirements, are highly product-specific.

Notwithstanding these problems, a number of studies indicate that non-tariff measures are widely applied to agricultural and food products in high-income countries, and increasingly low- and middle-income countries also (Ndayisenga and Kinsey, 1994; Thilmany and Barrett, 1997; Hillman, 1997).

Furthermore, over time the nature of these measures has changed with a decline in the incidence of quantitative restrictions and the increased incidence of technical measures such as sanitary and phytosanitary (SPS) and quality requirements. Moreover, an increasing proportion of agricultural and food products are simultaneously subject to more than one non-tariff measure.

Although it is recognised that technical barriers are a serious impediment to trade in agricultural and food products, economists have found it difficult to assess and/or measure their effects on trade flows. This reflects the multiple forms that technical barriers can take, ranging from outright import bans, product and process standards to labelling requirements, and their highly product-specific nature. Furthermore, individual products are typically subject to a range of technical measures, the individual impact of which is difficult to measure.

### **11.2.2. Technical barriers to trade: Definition and classification**

The definition of technical barriers to trade adopted here is that of Roberts and De Kremer (1997):

"Standards governing the sale of products into national markets, which have as their *prima facie* objective the correction of market inefficiencies stemming from externalities associated with the production, distribution and consumption of these products".

These measures aim to prevent the entry into national markets of products that fail to meet pre-specified standards. In this context, "standards" are technical specifications relating to characteristics of products and/or the manner in which they are produced.<sup>143</sup> Equivalent measures may or may not be applied to domestic products, depending on their relative characteristics and the risks that pre-specified standards will be violated.

A variety of policy instruments can be employed by governments to correct (real or perceived) market failures. Our interest here is in those measures that are applied to imports (Figure 11.2). Three broad categories of measures are usually applied (Roberts *et al.*, 1999). Firstly, import bans prohibit the entry of a product entirely, from a particular country/region or at a specific time of the year. These are most widely applied to products that pose a great risk to human, plant or animal health and where alternative methods of control are technically or economically infeasible. Secondly, technical specifications define technical requirements that products must satisfy in order to be permitted entry. These can encompass the characteristics of the product itself, the process by which it is produced

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<sup>143</sup> Although the term "standard" is often employed to refer to non-mandatory measures (indeed this is the language of the TBT Agreement), in this context it refers to all forms of technical specification whether mandatory or non-mandatory.

and/or the manner in which it is packaged. Predefined methods of conformity assessment are specified to determine whether the product is in compliance and can be permitted to enter. Thirdly, information measures require certain information to be disclosed on the product label and/or control the claims that can be made about the characteristics of the product.

**Figure 11.2. Classification of technical barriers to trade**

Import Bans		Technical Specifications			Information Requirements	
Total Ban	Partial Ban	Process Standards	Product Standards	Technical Standards	Labelling Requirements	Controls on Voluntary Claims

Source: Roberts (1998); Roberts et al. (1999)

Technical barriers to trade are applied to address a wide range of societal interests, notably protecting the economic interests of suppliers (agricultural producers, food processors, etc.), the health and economic interests of food consumers, and the natural environment (Figure 11.3) (Roberts et al., 1999). For each of these objectives a distinction can be made between measures associated with risks to human, plant or animal health or the environment, or other societal objectives, for example protecting the economic interests of consumers. A similar distinction is applied to determine measures covered by the SPS and TBT Agreements within the WTO.

**Figure 11.3. Classification of technical barriers to trade by objective:**

Societal Interests	Risk-Reducing Measures	Non Risk-Reducing Measures
Suppliers	Protection of commercial animal/plant health	Compatibility of products
Consumers	Food safety	Quality characteristics
Natural Environment	Protection of natural environment from harmful non-indigenous species	Environmental conservation

Source: Roberts et al. (1999)

Technical measures also differ in the extent to which they discriminate between domestic and imported products. Non-discriminatory measures are applied equally to domestic and imported products, although differences may remain in the manner in which conformity assessment is

undertaken.<sup>144</sup> Discriminatory measures apply additional and/or qualitatively different requirements to imported products. Furthermore, measures can be applied to all imports regardless of source or discriminate between individual exporting countries. The extent to which technical measures discriminate between products according to source is an important factor influencing the impact on trade, both in terms of total trade flows and flows between particular countries.

Whereas much of the concern about the impact of SPS standards on trade has concentrated on mandatory government requirements, there is growing awareness that voluntary standards can also impede trade. Firstly, compliance with established voluntary standards might be essential because consumers require compatibility with complementary products or services (for example plastic containers and microwave ovens). Secondly, voluntary standards may be closely related to consumer preferences (for example safety marks that are seen by consumers as an essential guarantee of minimum product quality). Thirdly, voluntary standards may be considered crucial for compliance with mandatory standards (for example ISO 9000 as a means to satisfy the requirements of food safety regulations). If such standards are so widely applied that they become *de facto* mandatory, there may in practice be little choice but for foreign suppliers to comply.

In addition to the standards associated with technical barriers to trade, the methods applied to assess conformity can also discriminate between domestic suppliers and exporters, often explicitly by applying additional or different methods of conformity assessment to imports. For example, imports are frequently subject to inspection at the border, whilst domestic producers are not subject to an equivalent process of positive release.

### ***11.2.3. Understanding the impact of technical measures on trade***

The trade impacts of technical barriers to trade can be conveniently grouped into three categories. All of these can be observed and represented in the simple classification detailed above:

- Prohibit trade by imposing an import ban or by prohibitively increasing production and marketing costs.
- Divert trade from one trading partner to another by laying down requirements that discriminate across potential supplies.
- Reduce overall trade flows by increasing costs or raise barriers for all potential suppliers.

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<sup>144</sup> Imported products may be subject to border inspection, whereas no comparable system of inspection is applied to domestic products.

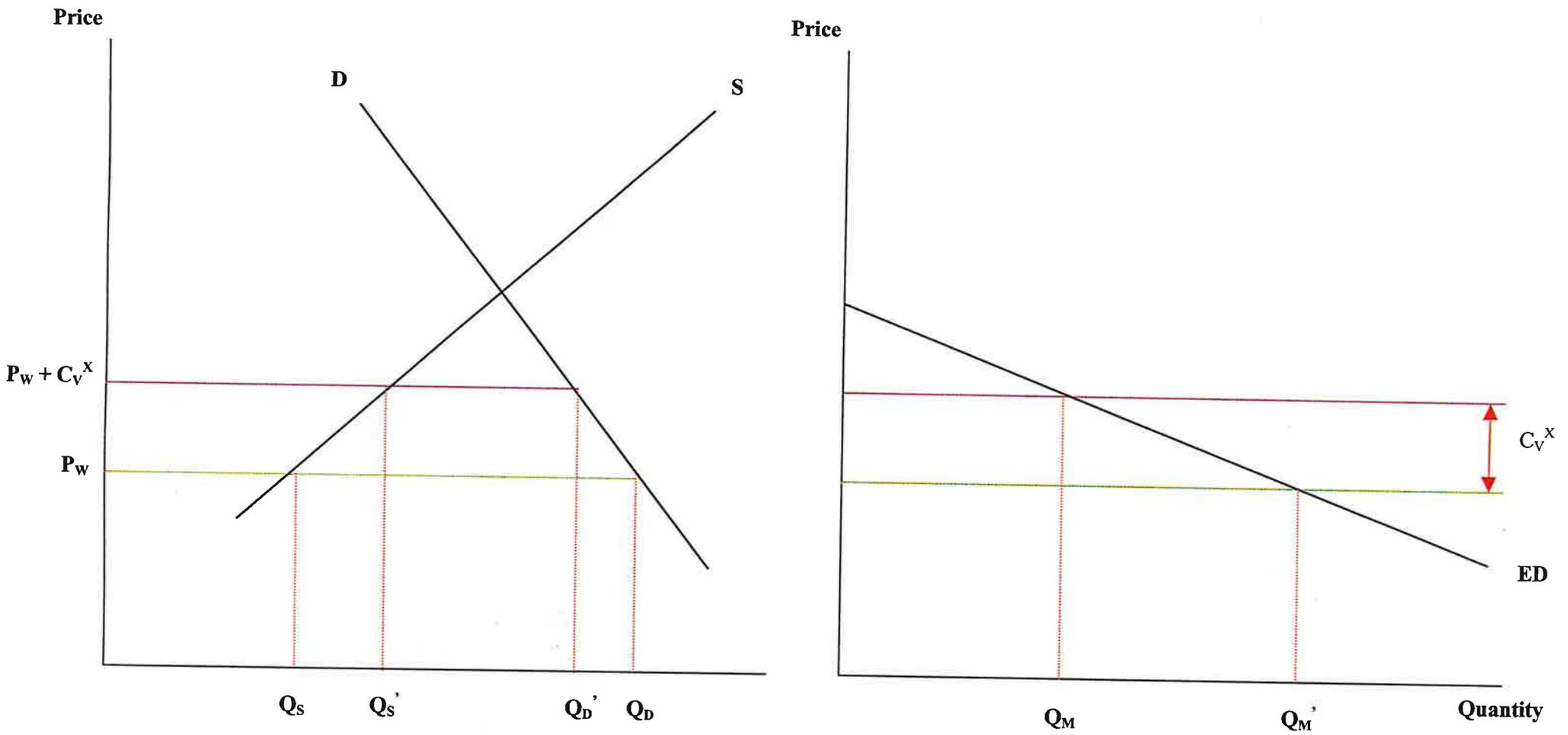
Economists have faced significant problems conceptualising and, to an even greater extent, measuring the impact of technical barriers to trade. This reflects the number and detailed nature of technical measures applied to agricultural and food products. Furthermore, the impact of technical barriers, unlike tariffs, is indirect through the costs of compliance that exporters face and these must be separated out from the other additional costs associated with trade, including the effects of traditional barriers such as tariffs.

To fully understand the impact of technical barriers to trade requires detailed knowledge of the standards and conformity assessment procedures that are applied, the manner in which individual suppliers comply with these requirements and the associated costs. This suggests that investigation of the impact of technical barriers to trade needs to be undertaken at the level of the individual suppliers. At the same time, however, there is a need to generate general conclusions about the impact of technical barriers to trade on trade flows by applying a more general model. This is the objective of this paragraph.

A number of previous studies have applied a simple small-country model within a static partial equilibrium framework to analyse the impact of technical barriers to trade (see for example Krissoff and Calvin, 1997; Sumner and Lee, 1997; Thilmany and Barrett, 1997; Roberts *et al.*, 2000). Importers are required to comply with specified technical requirements, compliance with which imposes additional costs, increasing the supply price above the world market price in a similar manner to a tariff. This so-called "tariff equivalent" will be equal to the costs of compliance and, provided estimates of supply and demand elasticities are available, it is possible to estimate the impact on trade volumes.

An example is provided in Figure 11.4, in which a technical measure is applied unilaterally to all exports by a single importer. Prior to the imposition of the measure, domestic producers face the world price ( $P_w$ ) and the quantity imported is  $Q_M$  (equal to  $Q_D - Q_S$ ). Implementation of the measure imposes costs of compliance equal to  $C_V^X$  on exporters, increasing the price to  $P_w + C_V^X$  and reducing imports to  $Q_M'$ .

Figure 11.4. Simple model of impact of technical barriers to trade - importer side:



From the exporter's perspective, what matters is who bears the costs of compliance? This depends on the ability of the exporter to avoid the costs of compliance by diverting trade to other markets that do not apply the measure. The alternative scenarios are summarised in Figure 11.5 (Roberts *et al.*, 1999). In the case of a measure applied by a single importer, exporters will switch to alternative markets and, although individual suppliers that have built up a market in the country concerned may be adversely affected, the overall impact will be negligible. If the measure is applied against the exporter by all, or a significant number, of importing countries, however, the scope to switch markets is constrained and the exporter will bear some or all of the costs of compliance. In this case the exporter will supply at the world price ( $P_w$ ) but in effect will receive a price of  $P_w - C_v^X$  (Figure 11.6).

The foregoing discussion assumes the importer is a "small country". If this assumption is relaxed and/or all importing countries apply the considered measure the "small country" assumption will be violated and the world market price will shift. In this way, the costs of compliance with the technical measure will be distributed between importers and exporters according to the responsiveness of the supply and demand schedules.

**Figure 11.5. Incidence of costs of compliance with technical barriers to trade**

		Number of exporters to which measure applied	
		One Exporter	All Exporters
Number of importers applying measure	One Importer	Can avoid compliance costs by diverting to alternative markets	Importer bears costs of compliance as increase in supply price
	All Importers	Exporter bears costs of compliance	Costs of compliance shared between importers and exporters through shifts in world price

Source: Roberts et al. (1999)

Figure 11.6. Simple model of impact of technical barriers to trade - exporter side

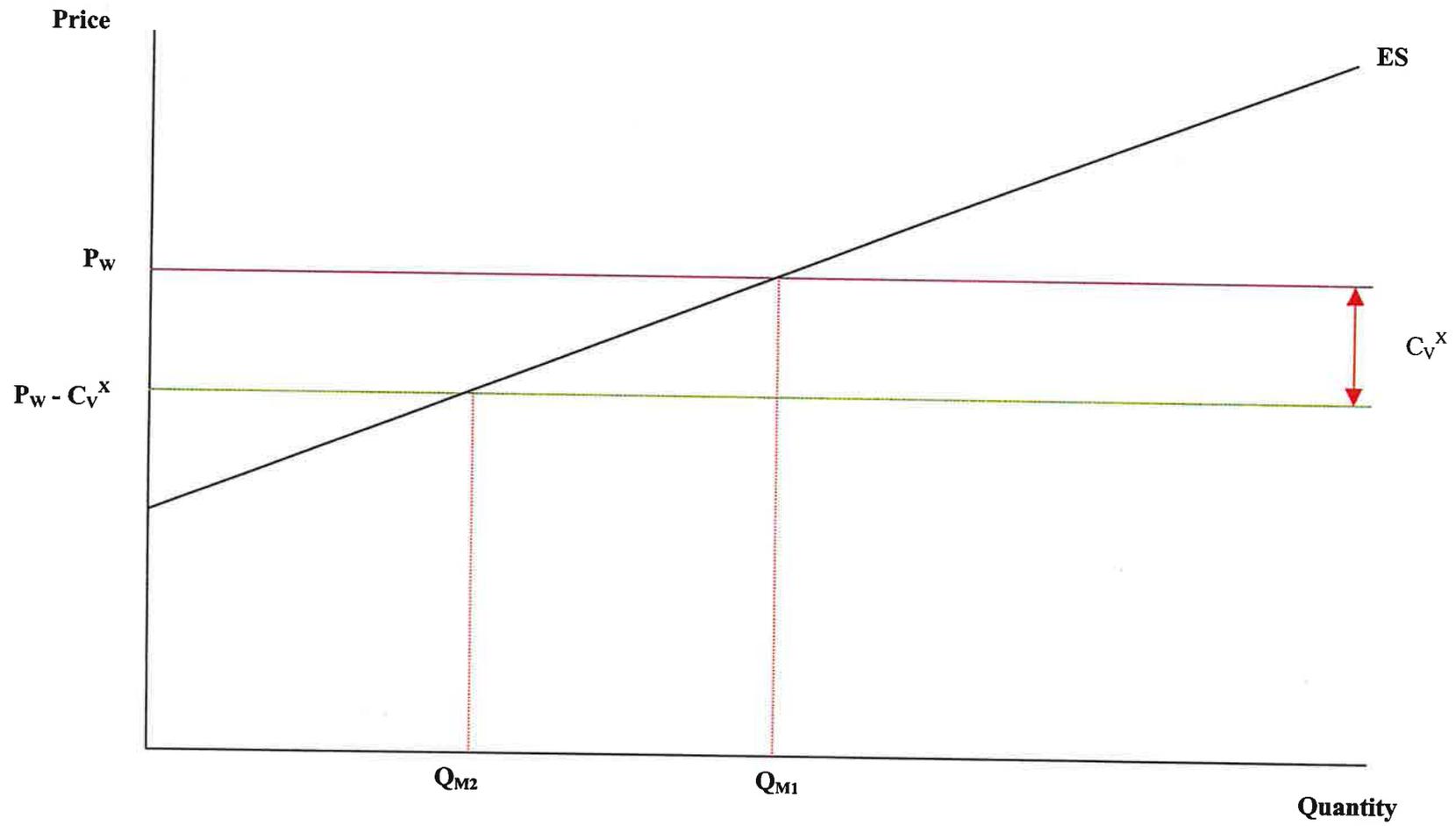


Figure 11.7. Impact of technical measure applied to both exporters and domestic suppliers

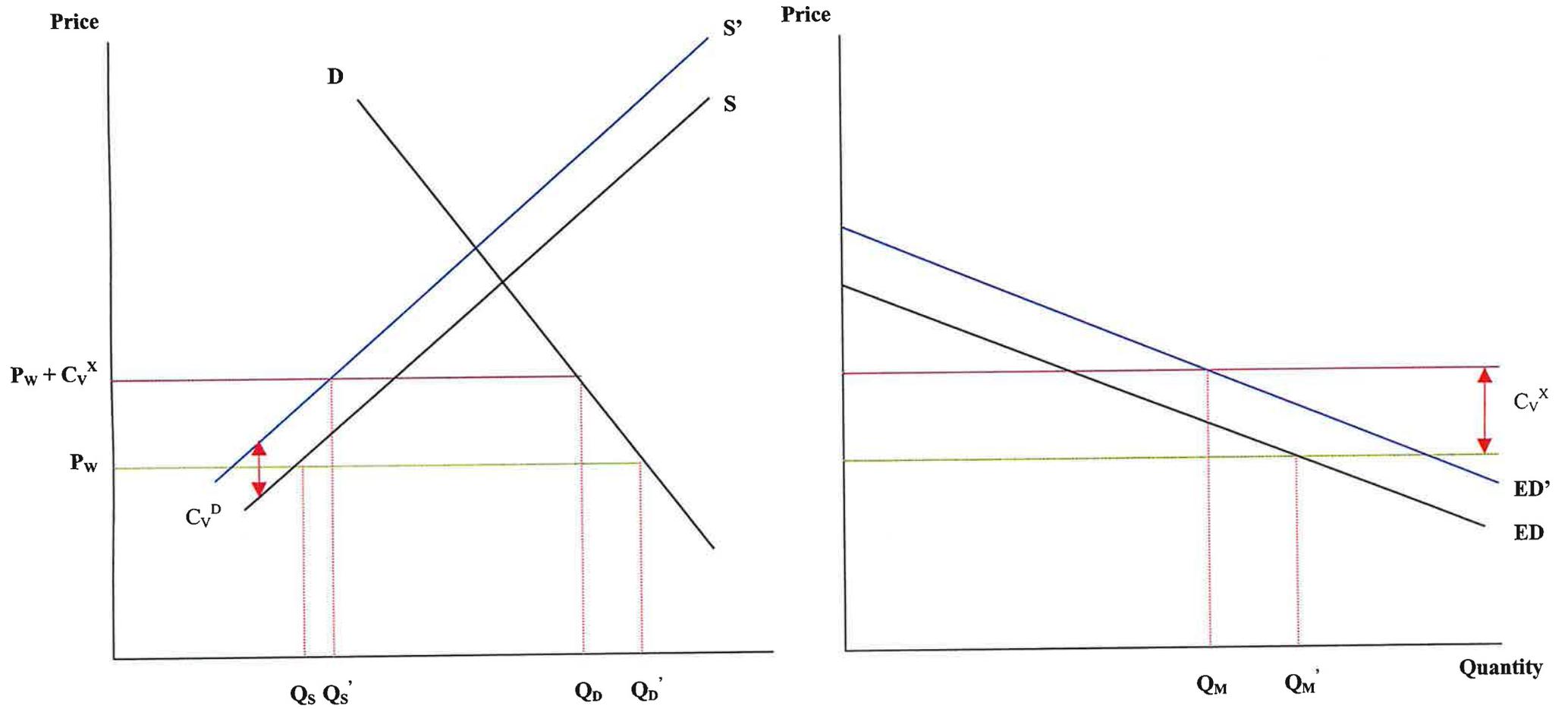
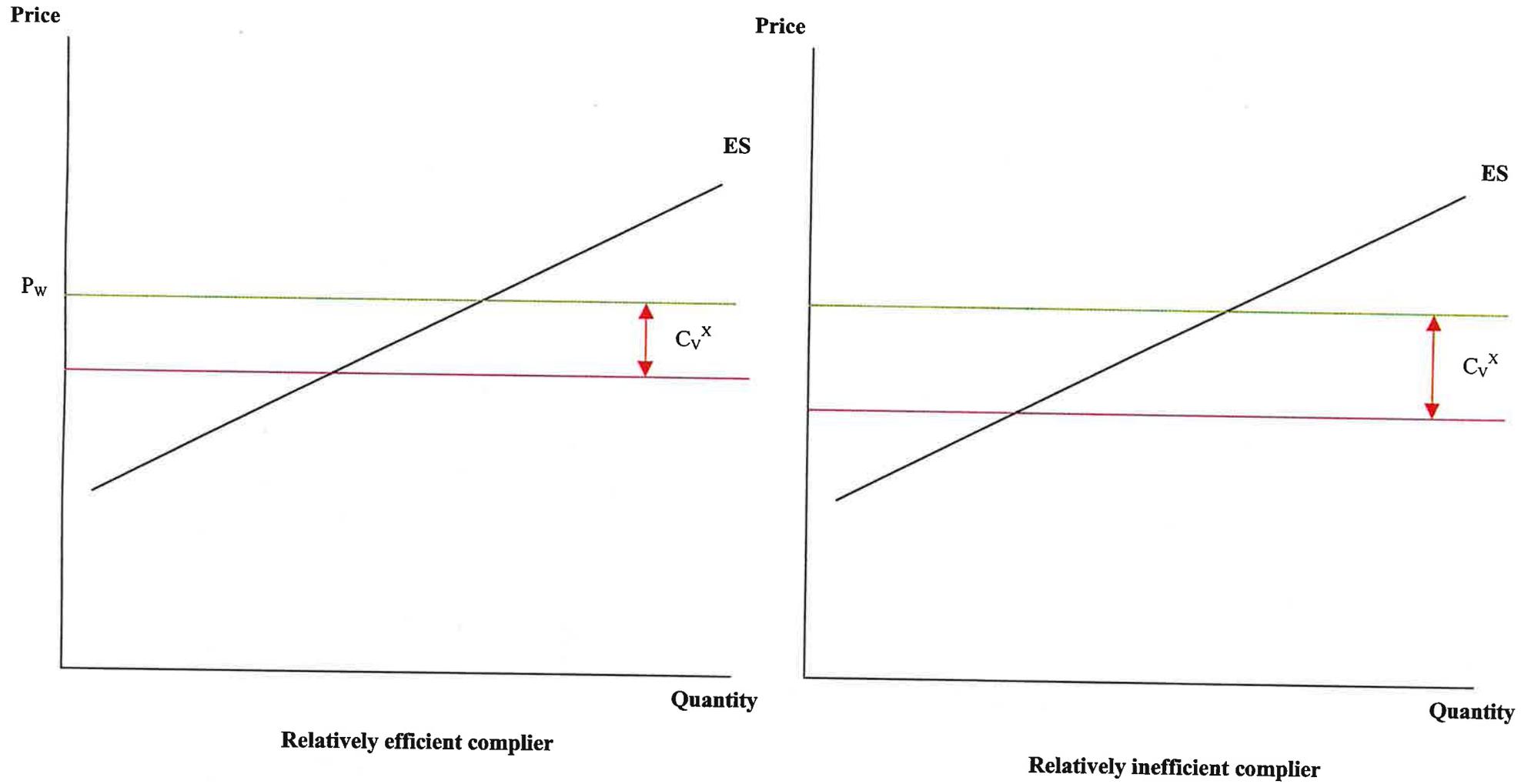


Figure 11.8. Impact of differences in compliance costs between individual exporters



#### 11.2.4. Measuring the impact of technical measures on trade

In practice, estimating the trade effects of non-tariff measures (NTMs) is difficult. Firstly, the complex and diverse effects detailed above can be difficult to disentangle and differ at the level of both individual suppliers and countries. Secondly, it may be difficult to separate out the effects of other factors from the impact of NTMs. Thirdly, products may be subject to a multitude of NTMs that differ in their nature and effects on trade.

Generally, four basic approaches to the estimation of the magnitude of NTMs are applied (see for example Deardorff and Stern, 1997; Laird, 1997; Hilman, 1991). Maskus *et al.* (2000) provides a review of the application of these methods to technical measures. These are discussed in turn below.

##### 11.2.4.1. Frequency/inventory-based measures

From data on the incidence of NTMs it is possible to construct frequency-based measures of the occurrence of NTMs (Deardorff and Stern, 1997; Laird, 1997). Such measures may be unweighted, or weighted by volume/value of imports or production. The most widely used data for this purpose is derived from UNCTAD's Database on Trade Control Measures.

Two measures are commonly calculated. The Trade Coverage Ratio (TCR)  $C_{jt}$  estimates the percentage of trade subject to NTMs, in total or of a particular type, for an exporting country  $j$  at a particular level of product aggregation:

$$C_{jt} = \left[ \frac{\sum D_i V_{it}}{\sum V_{it}} \right] \cdot 100$$

where  $D_i$  is a dummy variable that takes the value of one if a technical measure is applied and zero otherwise;  $V_i$  is the value of imports of tariff line  $i$ ;  $t$  is the year of measurement of the technical measure and  $T$  is the year of the import weights.

A key problem with this measure, however, is the endogeneity of the import value weights. For example, if an NTM is so restrictive that it precludes all imports of item  $i$  from country  $j$ , the weight  $V$  will be zero (Laird, 1997). Consequently the TRC is downward-biased. Furthermore, the TRC does not indicate the extent to which NTMs reduce the value of imports of the affected items, thus reducing the weight of restricted items in the total value of a country's imports.

An alternative measure that overcomes the problem of endogeneity of the import value weights is the frequency index (FI)  $F_{jt}$ :

$$F_{jt} = \left[ \frac{\sum D_{it} V_{it}}{\sum M_{it} V_{it}} \right] \cdot 100$$

where  $D_i$  is a dummy variable that takes the value of 1 if a technical measure is applied and zero otherwise;  $M_i$  is a dummy variable that takes the value of 1 if there are imports from the exporting country  $j$  and zero otherwise;  $t$  is the year of measurement of the technical measure and  $T$  is the year of the import weights.

The FI does not reflect the relative weight of the affected products and, as a consequence, does not give any indication of the importance of NTMs to an exporter overall, or between export items.

#### 11.2.4.2. Price-comparison measures

An alternative and more informative approach for assessing the impact of NTMs is to measure the impact on the domestic price of a good subject to NTMs in comparison to some reference price. Once the impact of other factors on domestic price have been taken into account, for example tariffs and transport costs, such a comparison provides some indication of the net effects of NTMs that are present in a market (Deardorff and Stern, 1997).

This approach generally involves measurement of the extent to which the domestic border price of the imported good exceeds the price paid by domestic importers to foreign exporters, inclusive of transport costs and any tariffs applied by the country concerned (Baldwin, 1991). This measure is termed a "tariff equivalent" because under conditions of perfect competition, an ad-valorem tariff at this rate would create the same wedge between the domestic and import prices. Tariff equivalents can be estimated in two ways (Moroz, 1985). Firstly, by observing the world price of the imported product and the domestic price at which it is sold, taking account of marketing margins, transport costs and tariffs. Secondly, using data on changes in marketed quantities due to the imposition of a technical barrier to trade and estimating the impact on prices using demand and supply elasticities.

To date, the price-comparison approach has been most widely applied in studies that have attempted to estimate the costs of compliance with technical measures and express it as a "tariff-rate equivalent" (Baldwin, 1991; Baldwin, 1970; Roningen and Yeats, 1976; Calvin and Krissoff, 1998). A number of these studies have employed partial equilibrium frameworks to separate out the impact of technical measures from other factors (for a review see Maskus *et al.*, 2000). For example, Paarlberg and Lee (1998) study the impact of US protection against imports from countries with food and mouth disease (FMD) and, more specifically, the optimal tariff to maximise social welfare. This approach, however, is dependent on the ability to isolate the impact of technical measures from other influences on market prices. In the case of products that are subject to numerous and complex technical requirements and other market-based influences, this can be problematic.

#### 11.2.4.3. *Quantity-type measures*

Given that the imposition of NTMs acts to shift the import demand curve for a product, measurement of the impact of the measure can focus on import quantities rather than prices. Indeed, it has been argued that a quantity measure is preferable to a price-comparison measure given that it is the impact of NTMs on traded quantities that is our primary interest (Jager and Lanjouw, 1977). However, unlike the price-comparison approach, there is a lack of any direct measure of the impact of NTMs – whilst it is possible to observe the quantity of a product imported there is no reference quantity against which to make a comparison.

The most widely applied approach to measure the quantity effects of NTMs uses cross-commodity or cross-country regression models to determine the impact of various determinants on trade, including NTMs. The aim is to identify the level of trade in the absence of the applied NTMs and to compare this to the level of trade that actually occurred.

The most widely applied framework is the gravity model, which has been developed to investigate the magnitude of trade flows between countries. For example, Swann *et al.* (1996) and Moenius (1999) explore the impact of a country's stock of voluntary standards on the value of trade flows. Likewise, Otsuki *et al.* (2000) employ a gravity model to estimate the impact of new EU legislation on aflatoxins in cereals, dried fruit and nuts on exports from nine African countries (see below).

#### 11.2.4.4. *Compliance cost-based measure*

The compliance cost approach aims to quantify the impact of NTMs on the import price directly through estimation of costs of compliance given the specific requirements imposed on importers. This involves identification of the specific changes and procedures businesses are required to undertake to comply with technical measures (Henson, 1997). This typically consists of two stages:

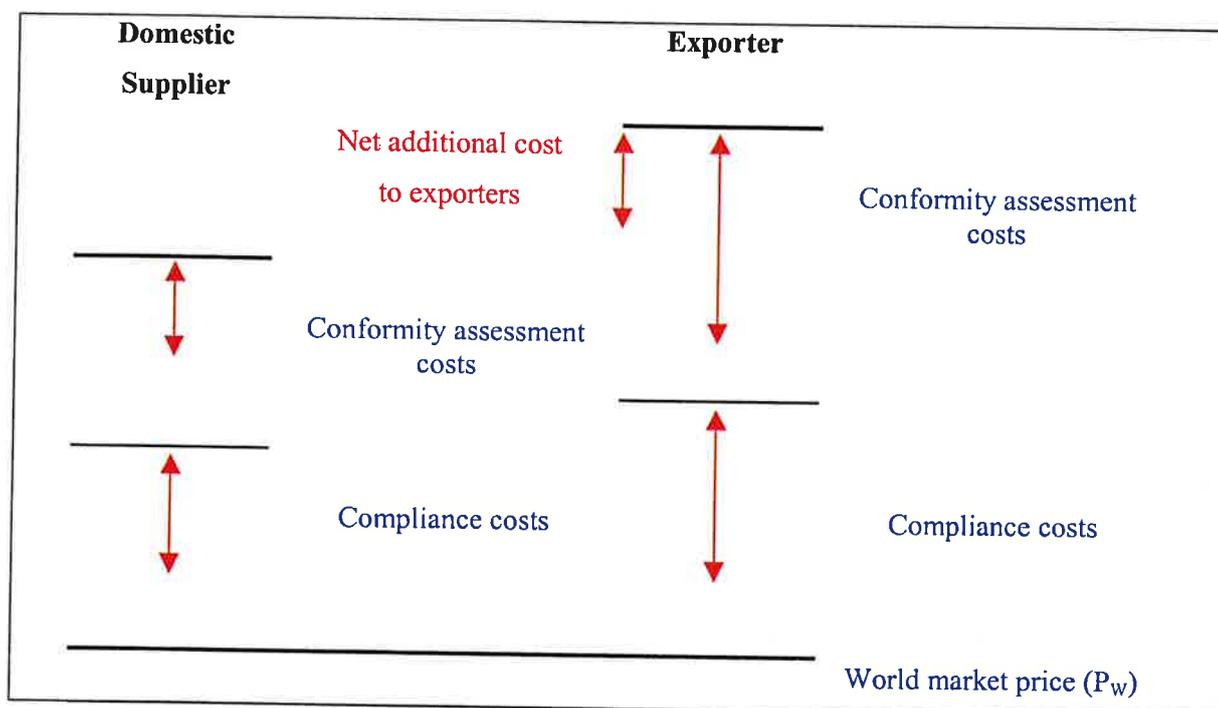
- Adaptation of the production processes and/or the final product to facilitate compliance with the specified standard.
- Production and supply of the product complying with the specified standard and compliance with conformity assessment procedures.

Stage one of this process is associated with non-recurring costs of compliance - one-off expenditure required to achieve compliance with the standard and thus facilitate entry to the market. This will determine the ability and/or willingness of exporters to comply with the specified standard and supply the export market. Stage two is associated with recurring costs of compliance - additional production and other supply costs required to supply product that is in compliance and to demonstrate compliance has been achieved. This will determine the extent to which exporters that are able to comply face

measures that increase their costs over and above those of domestic suppliers (Figure 11.9) (Josling, 1994; FAO, 1995).

The costs of compliance with the specified technical measure are estimated on a case-by-case basis using actual or reported cost data. Whereas the direct approach is demanding in its data requirements and more costly to undertake, the results are generally more reliable and can be related back to the characteristics of particular standards and conformity assessment procedures, indicating which has the greatest impact on market price.

**Figure 11.9. Recurring costs of compliance with technical measures**



The foregoing discussion suggests that the impact of non-tariff measures on market price is dependent on the magnitude of the associated costs of compliance. In turn, costs of compliance are influenced by the availability of resources at both the firm and national levels. Thus, suppliers in two exporting countries that face the same technical measure may have different costs of compliance according to the availability of compliance resources such as basic infrastructure (for example laboratories, research institutes, nature of the marketing chain, etc.). Likewise, individual firms within one exporting country may have different costs of compliance according to how well they are endowed with compliance resources (for example laboratories, human capital, production facilities, etc.). Thus the costs of compliance with technical measures and the consequent impact on market price can be conceptualised in terms of a matrix of country- and firm-specific compliance costs (Figure 11.10).

**Figure 11.10. Matrix of costs of compliance with non-tariff measures:**

	Domestic Supplier	Exporter I	Exporter II	Exporter III	Exporter IV
Market I					
Market II					
Market III					
Market IV					
Market V					

Because of the resource-intensity of this approach, there are relatively few published studies that estimate compliance costs directly. Exceptions, however, include Cato (1998) and Saqib (1999). For example, Cato (1998) assesses the impact of EU hygiene standards on the Bangladeshi shrimp sector. Over the period August to December 1997, exports of frozen shrimps from Bangladesh were banned by the European Commission because of concerns about hygiene standards in processing facilities and the efficiency of controls undertaken by Bangladeshi government inspectors. It is estimated that the loss of export revenue as a result of this ban was \$14.6 million. Furthermore, the costs of upgrading sanitary conditions in the frozen shrimp industry to satisfy the EU's hygiene requirements over the period 1997-98 is estimated to have been \$17.6 million; an average expenditure per plant of \$239,630.

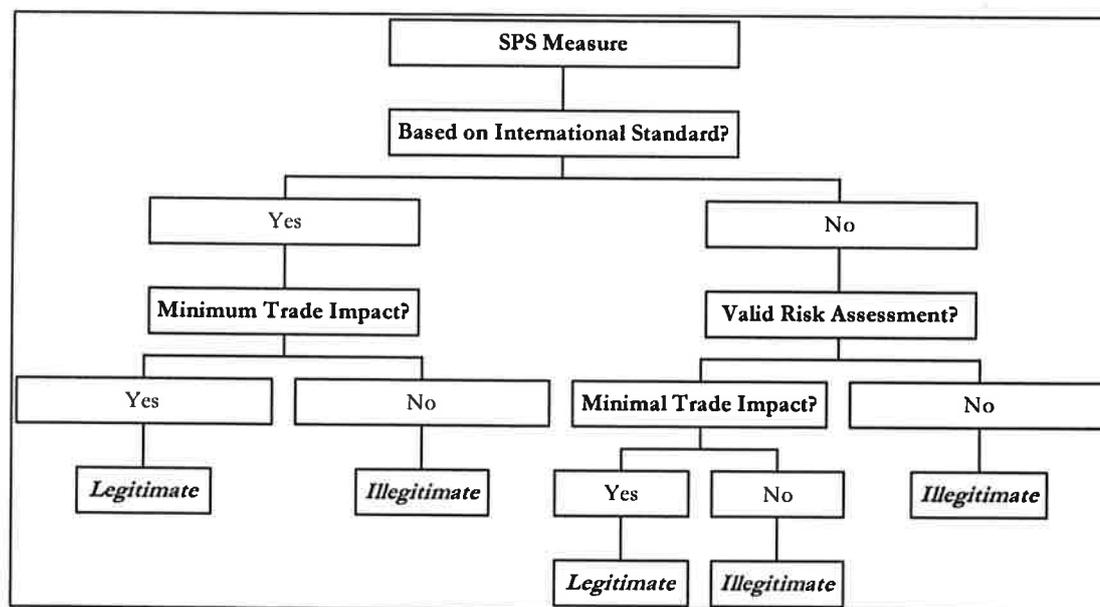
#### *11.2.5. Legitimacy of non-tariff measures*

The question of whether non-tariff measures are justified depends on the specific nature of the measure, its objectives and the potential impact on trade. In the case of SPS measures, for example, this is essentially a scientific issue – does the measure address a real risk to human, animal or plant health? In the context of international trade, clear pre-defined standards are required to judge legitimacy and well-structured and transparent procedures for settling disputes. One example, which is very relevant to agricultural and food markets is the justification of measures under the SPS Agreement. This Agreement essentially requires nation states, when challenged, to justify the SPS measures they apply and demonstrate that any trade effects are proportionate.

There are two approaches through which SPS measures can be justified (Figure 11.11). Firstly, through the adoption of international standards, in particular those of Codex Alimentarius, OIE and IPPC, which are automatically assumed to comply with the provisions of the Agreement. Secondly, through an assessment of the risks to human, animal or plant health addressed by the measure. Given that many countries choose to adopt different/higher standards than those specified by the international standards-setting organisations, risk assessment is a key element of the discipline laid down by the Agreement.

The WTO has clearly defined procedures for dispute settlement that can be invoked once bilateral negotiations between trading partners have failed. However, it is evident that, because of the great resource costs involved, dispute settlement is only pursued as a last resort and when there is sufficient economic and/or political impetus. In the case of the SPS Agreement, for example, only three cases have been pursued through the dispute settlement procedures since 1995, although all of these went through to the Appellate Body.

**Figure 11.11. Assessment of SPS measures under the SPS Agreement**



Source: Hooker and Caswell (1999)

### 11.2.6. The impact of technical barriers to trade: Empirical evidence

There is a paucity of studies that assess the trade and other impacts of technical measures, particularly in the context of food and agricultural product exports. Of those studies that have been undertaken, the vast majority has attempted to quantify the impact on agricultural and food exports from the United States. A number of key studies are reviewed briefly below.

Roberts and De Kremer (1997) and Thornsbury et al. (1998) report the result of a survey of USDA personnel in 132 countries that aims to identify "questionable" technical measures that threaten, constrain or prevent US exports of agricultural and food products. These measures are classified according to the typology detailed in Figures 11.2 and 11.3 (Roberts et al., 1999) (Table 11.1). The estimated total impact of these measures on US exports of agricultural products in 1996 is \$4907 million (Table 1). Of this, 90 per cent is due to SPS measures. The impact of food safety standards in particular is estimated to have been around \$2,288 million (Table 11.2).

**Table 11.1. Technical barriers to US agricultural and food exports, 1996**

Regulatory Goal	Risk-Reducing Measures			Non-Risk-Reducing Measures			Non-Classifiable	Total
	Food Safety	Animal and Plant Health	Natural Environment	Quality Attributes	Compatibility	Conservation		
Total Bans	12	56	3	1	0	0	0	72
Partial Bans	0	21	0	0	0	0	0	21
Input Standards	0	0	0	0	0	0	0	0
Process Standards	32	78	1	15	0	0	0	126
Product Standards	26	33	0	13	0	0	0	72
Packaging Standards	1	0	0	2	5	0	0	8
Label Requirements	2	2	2	7	0	1	0	14
Controls on Voluntary Claims	0	0	0	1	0	0	0	1
Non-Classifiable	3	20	0	0	0	0	2	25
<b>Total</b>	<b>76</b>	<b>210</b>	<b>6</b>	<b>39</b>	<b>5</b>	<b>1</b>	<b>2</b>	<b>339</b>

Source: Roberts et al. (1999)

**Table 11.2. SPS standards impeding agri-food exports from the United States, 1996**

Regulatory Goal	Number of Barriers	Estimated Trade Impact (\$ million)	Average Trade Impact per Barrier (\$ million)
Plant health	260	2516.79	17.02
Animal health		868.82	
Food safety		2288.00	
Natural environment		0.51	
Total		4424.73	

Note: Sum of estimated trade impact for individual regulatory goals may exceed overall trade impact for SPS measures because individual measures may have multiple regulatory goals.

Source: Thornsby et al. (1998)

Calvin and Krisoff (1998) assess the impact of phytosanitary standards on US imports of apples into Japan, South Korea and Mexico over the period 1994/95 to 1995/96. The impact of phytosanitary standards is estimated to be equivalent to a tariff rate of up to 58 per cent. Further, the analysis suggests that harmonising phytosanitary standards in these countries to those of the United States would have increased apple imports by \$205 million in 1994/95 and \$280 million in 1995/96.

Paarlberg and Lee (1998) examine the impact of US protection against imports from countries with food and mouth disease (FMD) and, more specifically, the optimal tariff to maximise social welfare. A partial equilibrium framework is applied to US beef imports, with nations categorised according to whether they are FMD-free or not. Patterns of tariffs with and without the risk of FMD infection are compared and found to be highly sensitive to the risk presented by imports and the assumed loss of output given an outbreak.

Orden and Romano (1996) model the effects of imported pests on domestic production and apply it to a US ban on imports of avocados from Mexico. The welfare effects of removing the ban involve a trade-off between reductions in the consumer price and the potential resource costs of producing avocados domestically given the risk of pest infestation.

Xia and Weyerbrock (1998) examine the impact of an EU ban on poultry exports from the United States introduced in 1997 and the welfare implications of proposed mandatory product treatment requirements. The ban has a minor impact, even if other exporters do not satisfy the gap left by US exports, because US exports of poultry prior to the ban were very small. The proposed mandatory product treatment requirements are found to lead to an increase in the EU poultry price and a welfare loss, unless consumer demand expands significantly in response to the introduction of these requirements.

Orden et al. (2000) employ a partial equilibrium model of world trade in poultry to explore the impact of sanitary requirements. In a market where a distinction is made between low- and high-value poultry, arbitrage opportunities can be created. Furthermore, the impact of these requirements depends on how widely they are applied across competing exporters.

Henson and Loader (1999) survey exporters of dairy products in the United States, Germany and the United Kingdom in an attempt to quantify the impact of food safety and other technical requirements in export competitiveness. These requirements are found to have a significant impact on certain types of exporters, in particular smaller companies and those involved with specialised and/or packaged products.

Otsuki et al. (2000) use a gravity-equation model to assess the impact of new EU standards for aflatoxins on exports of cereals, dried fruits and nuts from nine African countries. It is estimated that these standards will decrease African exports by 64 percent, equivalent to \$670 million/annum.

A broad indication of the impact of SPS requirements on exports of agricultural and food products is provided by data on rejections following border inspection in export markets. At the current time, these data are only systematically collected and publicly available for the United States (Table 11.3).

<sup>145</sup> Over the period June 1996 to June 1997, there were over 1,100 detentions of imports from Europe. The main reasons were suspected infringements of regulations on low-acid canned foods and product labelling. <sup>146</sup>

**Table 11.3. Number of contraventions cited for US Food and Drug Administration import detentions, June 1996 to June 1997**

Reason for Contravention	Africa	Latin America and the Caribbean	Europe	Asia	Total
Food additives	2 (0.7%)	57 (1.5%)	69 (5.8%)	426 (7.4%)	554 (5.0%)
Pesticide residues	0 (0.0%)	821 (21.1%)	20 (1.7%)	23 (0.4%)	864 (7.7%)
Heavy metals	1 (0.3%)	426 (10.9%)	26 (2.2%)	84 (1.5%)	537 (4.8%)
Mould	19 (6.3%)	475 (12.2%)	27 (2.3%)	49 (0.8%)	570 (5.1%)
Microbiological contamination	125 (41.3%)	246 (6.3%)	159 (13.4%)	895 (15.5%)	1,425 (12.8%)
Decomposition	9 (3.0%)	206 (5.3%)	7 (0.6%)	668 (11.5%)	890 (8.0%)
Filth	54 (17.8%)	1,253 (32.2%)	175 (14.8%)	2,037 (35.2%)	3,519 (31.5%)
Low acid canned foods	4 (1.3%)	142 (3.6%)	425 (35.9%)	829 (14.3%)	1,400 (12.5%)
Labelling	38 (12.5%)	201 (5.2%)	237 (20.0%)	622 (10.8%)	1,098 (9.8%)
Other	51 (16.8%)	68 (1.7%)	39 (3.3%)	151 (2.6%)	309 (2.8%)
Total	303 (100%)	3,895 (100%)	1,184 (100%)	5,784 (100%)	11,166 (100%)

Source: FAO (1999)

These studies indicate that technical measures can have a significant and complex impact on trade flows and welfare in both importing and exporting countries. However, given their limited coverage, they present a rather partial view of the impact of technical measures. Furthermore, they throw little light on the degree to which technical measures impact upon EU exports of agricultural and food products in particular. This is the subject of the following sections.

<sup>145</sup> These data are published by the US Food and Drugs Administration (FDA) and cover all food products except meat and poultry.

<sup>146</sup> These data must be treated with care when comparing between regions and/or individual countries. Clearly, the level of rejections will reflect the overall volume of trade. Furthermore these data take no account of product that is eventually imported after further testing and/or following treatment to bring it into compliance with US SPS requirements.

### 11.3. Frequency of US technical measures on agricultural and food products

Frequency-based measures attempt to estimate the number of technical measures applied by type across product categories. These measures typically make use of inventories of non-tariff measures, including technical measures, which detail the number and type of measure applied by tariff line. The most comprehensive is UNCTAD's Database on Trade Control Measures.

Frequency-based measures are employed in two ways. Firstly, to provide a simple measure of the frequency with which technical measures are applied by product, preferably according to defined tariff lines. Secondly, to measure the extent to which trade flows are covered by technical measures. In the latter case both the Trade Coverage Ratio (TCR) and Frequency Index (FI) are calculated.

Frequency-based measures have a number of limitations that must be borne in mind when interpreting the results. These include:

- Little or no distinction is made between technical measures according to their likely impact on trade. As such, therefore, the impact on trade is assumed to be a simple additive function of the number of measures applied. Furthermore, frequency-based measures do not provide any information on the deterrent effects that technical measures might have on the pricing and/or quantity decisions of foreign exporters.
- The reliability of frequency-based measures is reliant on the availability of a comprehensive database of technical measures that includes all of the substantive measures applied.
- The manner in which technical measures are categorised and the level and type of aggregation can differ between countries. This can cause problems in comparing the frequency and/or trade coverage of technical measures between countries and over time.

In this part of the project, two alternative analyses of the frequency of technical measures were undertaken for EU exports of agricultural and food products to the United States. Firstly, an inventory of technical measures was compiled for both the United States and EU to permit comparison of the number and types of measure applied. Secondly, the frequency of technical measures by tariff line (HS-02) was undertaken using data from UNCTAD's Database on Trade Control Measures.

In both cases legislation applicable to agricultural and food products was identified and the associated measures categorised according to:

- regulatory measure;
- regulatory objective;

- product (according to HS-02 tariff line).

In the case of both regulatory measure and objective, the taxonomy developed by Roberts et al. (1999) was employed, as described in section 11.2. This is detailed once again in Figure 11.9, which provides examples as illustration.

### ***11.3.1. The inventory database: A comparison of EU and US regulatory profiles***

To identify technical measures applied in the United States and EU, a review was undertaken of the relevant official publications. In the case of the United States this was the Code of Federal Regulation and in the case of the EU, the Official Journal of the European Communities. The reliability of the resultant database was tested through a process of repeat classification. This was undertaken by two individuals (without consultation) on a random sample of 5 percent of the identified regulations. The level of agreement between the two individuals was 86%, indicating a high level of reliability.

A total of 825 governmental regulations and standards laying down requirements for imports of agricultural and food products were identified, 534 for the United States and 291 for the European Union (Table 11.4). In the case of the US, the products most subject to technical measures are edible vegetables, roots and tubers, edible fruits and nuts, dairy products, eggs and honey and meat and edible meat offal. In the EU, the products most subject to technical measures are meat and edible offal, dairy products, eggs and honey, edible fruits and nuts, edible vegetables, roots and tubers, and fruit, vegetable and nut preparations.

Many agricultural and food products are simultaneously subject to multiple technical measures. Whilst it cannot be assumed that the trade effects of technical measures increase in direct proportion to the number of measures applied, it is reasonable to assume that the burden of compliance will increase. Figure 11.10 reports the proportion of tariff lines subject to multiple technical measures in the US as an example. Only 27 percent of tariff lines to which technical measures are applied are subject to only one measure. Around 67 percent of such tariff lines are subject to two measures and around 9 percent are subject to three or more.

Figure 11.9. Classification of technical measures with examples

Regulatory Measure	Regulatory objective					
	Risk-reducing measures			Non-risk-reducing measures		
	Food safety	Commercial animal and plant health protection	Protection of natural environment	Conservation	Quality attribute	Compatibility
Bans	Ban on imports of individual varieties or species of ingestible products harmful to human health	Ban (may be only seasonal) on imports to exclude or minimise risk of introduction of quarantine pests and diseases	Ban or regional ban to minimise risk of introduction of pests or diseases that threaten native flora or fauna	Ban or seasonal ban on imports that threaten global stock of endangered species	Ban on imports of products proscribed by state religion or inferior breeds or varieties	N.A.
Process standards	Measures that require specific time/temperature regimes for imported foods	Required treatments for products to prevent introduction of quarantine pests in production areas	Ban on imports of bioengineered products because of potential risks to native flora and fauna	Required harvesting techniques for imports of renewable resource-based products	Animal welfare measures	N.A.
Product standards	Measures that specify maximum residue levels for specified pesticides on horticultural products	Standards that establish threshold levels for presence of disease-causing organisms that threaten crops or livestock	Standards that establish threshold levels for presence of disease-causing organisms that threaten indigenous species	Measures that require harvested product to reach a certain size to prevent depletion of natural resource stock	Measures that regulate size, appearance and other attributes of agricultural products	N.A.
Packaging standards	Specifications for packaging technology that minimise probability of microbial contamination	Sealed container requirements for imported products to minimise probability of infestation of production areas	Sealed container requirements for imported products to minimise probability of introduction of harmful non-indigenous species	Requirement that packaging materials are biodegradable	Regulations that prohibit misleading or fraudulent packaging	Mandatory dimensions for wholesale and/or retail containers to facilitate handling/transportation in marketing channels
Labelling requirements	Requirements for labels that indicate safe handling procedures or whether product poses risks for sensitive sub-populations	Required labelling of individual items of produce or containers to minimise probability of infestation of production areas by illegally transhipped imports	Required labelling for safe handling of bio-engineered commodities and products so that they are not distributed outside circumscribed marketing channels	Mandatory eco-labels	Measures that mandate labels that indicate nutritional profile or whether the product contains bio-engineered ingredients	N.A.

Source: Roberts et al (1999)

**Table 11.4. Regulations laying down requirements for imports of agricultural and food products in the US and EU**

HS-2 Code	Product	USA	EU
1	Live animals	3	22
2	Meat and edible meat offal	45	45
3	Fish, crustaceans, molluscs etc.	11	15
4	Dairy products, eggs and honey	55	40
5	Other products of animal origin	2	4
6	Live plants, flowers etc.	7	10
7	Edible vegetables, roots and tubers	197	28
8	Edible fruits and nuts	132	32
9	Coffee, tea and spices	2	6
10	Cereals	9	8
11	Products of the milling industries (starch, gluten etc.)	1	6
12	Oilseeds	6	3
13	Gums, resins etc.	2	1
14	Other vegetable products	0	0
15	Animal and vegetable oils and fats	1	2
16	Preparations of meat and fish	6	7
17	Sugar and sugar confectionery	11	2
18	Cocoa and cocoa preparations	2	2
19	Cereal preparations	5	6
20	Fruit, vegetable and nut preparations	35	26
21	Other preparations	1	0
22	Beverages, spirits and vinegar	1	24
23	Residues and waste from food industry	0	2
Total		534	291

**Figure 11.10. Number of technical measures applied by the United States per tariff line**

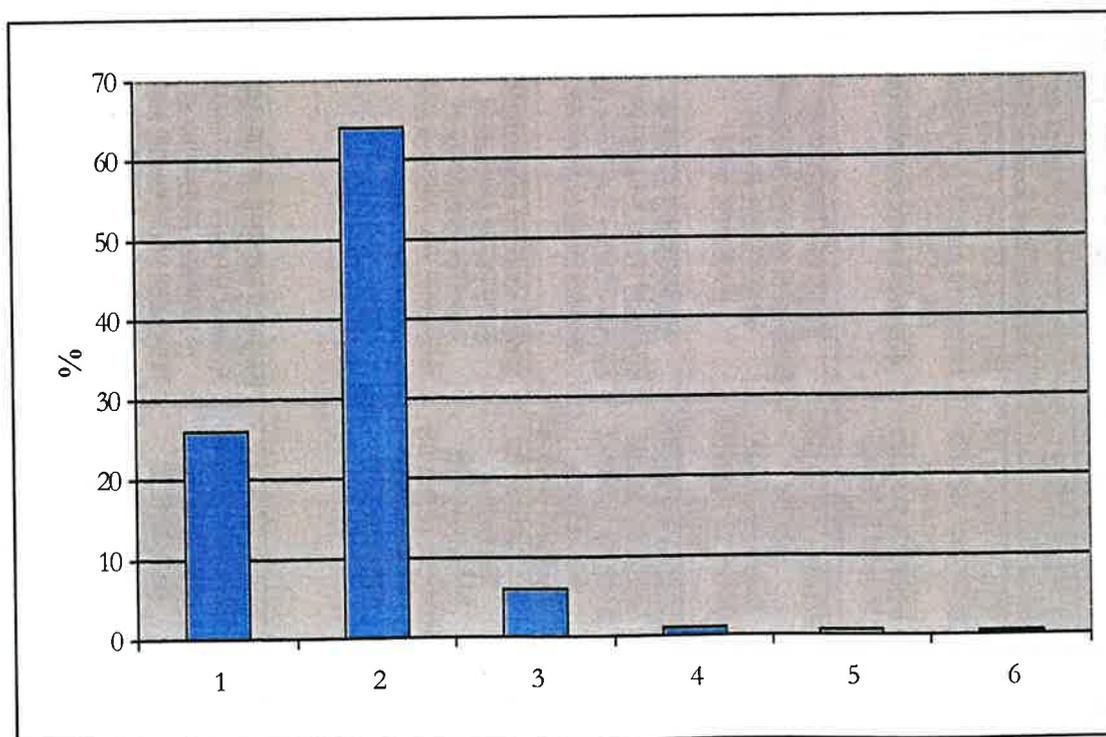
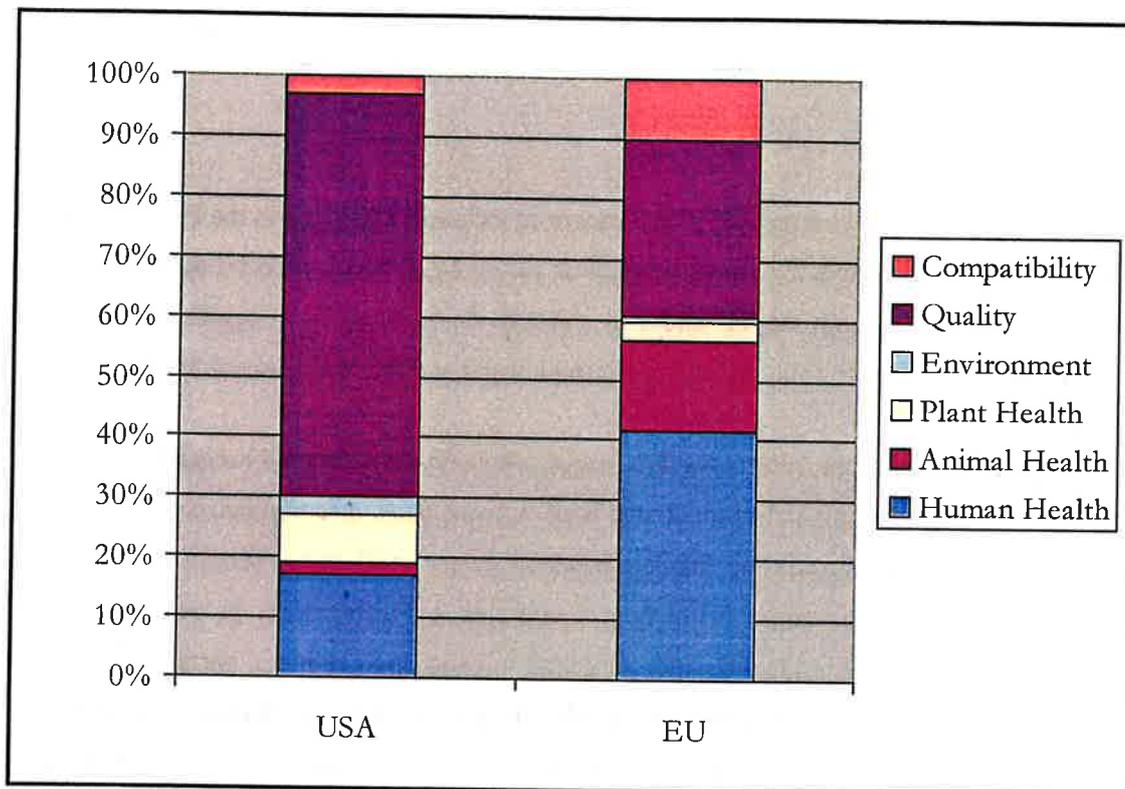


Figure 11.11 and Tables 11.5 and 11.6 provide a breakdown of technical measures applied to agricultural and food products in the EU and US by objective. In the US, 67 percent of measures have the quality of agricultural and food products as their objective – many of these are quality standards for agricultural products, for example fruit and vegetables. In the EU, the main objective of technical measures applied to agricultural and food products is the protection of human health, accounting for 47 percent of all of the measures applied.

**Figure 11.11. Distribution of technical measures by objective**



**Table 11.5. Distribution of technical measures by objective in the US**

Type of Measure	Human Health	Animal Health	Plant Health	Environment	Quality	Compatibility	Total
Ban	25%	6%	45%	25%	0%	0%	100%
Package	30%	0%	26%	22%	17%	5%	100%
Process	60%	2%	6%	4%	26%	2%	100%
Product	10%	1%	7%	1%	81%	0%	100%
Label	7%	1%	4%	3%	74%	11%	100%
Other	0%	0%	60%	40%	0%	0%	100%
Total	17%	2%	8%	3%	67%	3%	100%

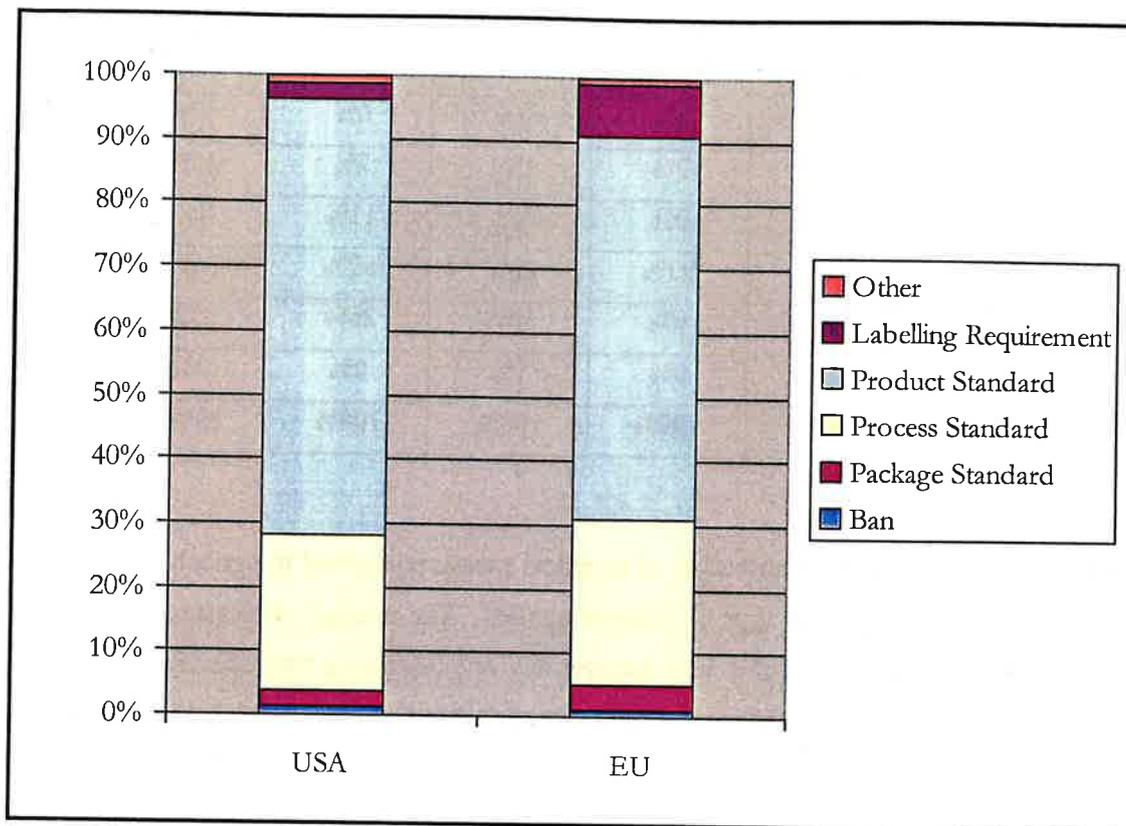
**Table 11.6. Distribution of technical measures by objective in the EU**

Type of Measure	Human Health	Animal Health	Plant Health	Environment	Quality	Compatibility	Total
Ban	57%	29%	14%	0%	0%	0%	100%
Package	45%	3%	0%	0%	29%	24%	100%
Process	52%	28%	0%	0%	16%	4%	100%
Product	40%	16%	5%	3%	31%	5%	100%
Label	29%	0%	0%	1%	50%	20%	100%
Other	0%	0%	0%	100%	0%	0%	100%
Total	42%	15%	3%	1%	30%	10%	100%

Figure 11.12 and Tables 11.7 and 11.8 provide a breakdown of technical measures in the EU and US by type of measure. The most trade distortive measures are total or partial bans, which prohibit trade outright. Bans are applied very infrequently in both the EU and US, although do account for a significant proportion of those measures applied for the protection of plant and animal health and the environment in the US.

In the case of technical specifications, *ceteris paribus*, process standards are generally regarded as potentially more trade distortive than packaging and product standards because costs of compliance tend to be higher. Packaging and product standards specify the characteristics of the end product but permit suppliers to adopt the most cost efficient process to comply with these requirements. Furthermore, process standards may conflict with prevailing systems of production and marketing in exporting countries, particularly in the case of low and middle-income countries (Henson et al., 2000). In general, process standards are applied more frequently in the US than the EU. For example, 56 per cent of technical measures in the US are process standards, compared to 21 percent in the EU. The predominant type of measure applied in the EU is product standards, which account for 55 percent of all measures applied.

**Figure 11.12. Distribution of technical measures by measure applied**



**Table 11.7. Distribution of technical measures by measure in the US**

Type of Measure	Human Health	Animal Health	Plant Health	Environment	Quality	Compatibility	Total
Ban	3%	13%	12%	15%	0%	0%	1%
Package	5%	0%	10%	19%	1%	4%	2%
Process	51%	25%	10%	15%	5%	10%	20%
Product	31%	49%	53%	23%	67%	4%	56%
Label	10%	13%	12%	20%	27%	82%	20%
Other	0%	0%	3%	8%	0%	0%	1%
Total	100%	100%	100%	100%	100%	100%	100%

**Table 11.8. Distribution of technical measures by measure in the EU**

Type of Measure	Human Health	Animal Health	Plant Health	Environment	Quality	Compatibility	Total
Ban	2%	3%	7%	0%	0%	0%	1%
Package	8%	1%	0%	0%	7%	21%	4%
Process	26%	38%	0%	0%	11%	9%	26%
Product	53%	58%	93%	83%	57%	35%	60%
Label	11%	0%	0%	16%	25%	35%	8%
Other	0%	0%	0%	1%	0%	0%	1%
Total	100%	100%	100%	100%	100%	100%	100%

Tables 11.9 and 11.10 report the distribution of technical measures applied to agricultural and food products by HS-2 tariff line and the type of measure applied. The number of measures exceeds the number of regulations reported in Table 11.4 because any one regulation may specify a number of technical measures. However, these data are broadly compatible to those in Table 11.4 in terms of the products that are most subject to technical measures. Products most subject to technical measures in the case of the US, and thus of particular interest to the current study, are:

- edible vegetables, roots and tubers;
- edible fruit and nuts;
- meat and edible meat offal;
- dairy products, eggs and honey.

Likewise, products that are most subject to technical measures in the case of the EU are:

- meat and edible meat offal;
- dairy products, eggs and honey;
- edible fruit and nuts;
- fruit, vegetable and nut preparations;
- edible vegetables, roots and tubers.

This analysis, based on the regulatory database, suggests that technical measures potentially have a greater impact on trade in the case of agricultural and food exports to the US than the EU. Firstly, technical measures are more frequently applied in the US. Secondly, the US apply potentially more trade distortive measures, namely product bans and process standards.

Table 11.9. Technical measures for agricultural and food products by form of instrument in the United States

HS-2 Code	Product	Ban	Specifications			Labelling	Other	TOTAL
			Packaging	Process	Product			
1	Live animals	0	0	6	0	2	0	8
2	Meat and edible meat offal	3	5	40	11	6	0	65
3	Fish, crustaceans, molluscs etc.	0	0	10	1	10	0	21
4	Dairy products, eggs and honey	0	2	20	33	1	0	56
5	Other products of animal origin	0	0	2	0	0	0	2
6	Live plants, flowers etc.	4	2	3	1	1	1	12
7	Edible vegetables, roots and tubers	0	3	32	149	58	0	242
8	Edible fruits and nuts	2	0	16	123	50	2	193
9	Coffee, tea and spices	0	0	0	2	0	0	2
10	Cereals	0	2	0	7	2	0	11
11	Products of the milling industries (starch, gluten etc.)	0	1	0	0	0	0	1
12	Oilseeds	0	0	2	4	2	0	8
13	Gums, resins etc.	0	2	0	0	0	0	2
14	Other vegetable products	0	0	0	0	0	0	0
15	Animal and vegetable oils and fats	0	0	0	0	1	0	1
16	Preparations of meat and fish	0	0	4	2	0	0	6
17	Sugar and sugar confectionery	0	0	6	7	0	0	13
18	Cocoa and cocoa preparations	0	0	0	2	0	0	2
19	Cereal preparations	0	0	0	5	0	0	5
20	Fruit, vegetable and nut preparations	0	0	0	34	2	0	36
21	Other preparations	0	0	0	1	0	0	1
22	Beverages, spirits and vinegar	0	0	0	1	0	0	1
23	Residues and waste from food industry	0	0	0	0	0	0	0
<b>Total</b>		<b>9</b>	<b>17</b>	<b>141</b>	<b>383</b>	<b>135</b>	<b>3</b>	<b>688</b>

**Table 11.10. Technical measures for agricultural and food products by form of instrument in the European Union**

HS-2 Code	Product	Ban	Specifications			Labelling	Other	TOTAL
			Packaging	Process	Product			
1	Live animals	2	2	11	19	0	0	34
2	Meat and edible meat offal	1	2	28	34	3	0	68
3	Fish, crustaceans, molluscs etc.	0	0	8	16	0	0	24
4	Dairy products, eggs and honey	0	4	23	31	4	0	62
5	Other products of animal origin	0	0	2	3	0	0	5
6	Live plants, flowers etc.	0	0	12	8	0	0	20
7	Edible vegetables, roots and tubers	0	0	3	30	0	0	33
8	Edible fruits and nuts	1	0	4	33	0	0	38
9	Coffee, tea and spices	0	2	3	6	3	0	14
10	Cereals	0	0	3	15	0	0	18
11	Products of the milling industries (starch, gluten etc.)	0	0	4	6	0	0	10
12	Oilseeds	0	0	2	4	0	0	6
13	Gums, resins etc.	0	0	0	1	0	0	1
14	Other vegetable products	0	0	0	0	0	0	0
15	Animal and vegetable oils and fats	0	0	0	4	0	0	4
16	Preparations of meat and fish	0	0	4	8	0	0	12
17	Sugar and sugar confectionery	0	1	1	1	0	0	3
18	Cocoa and cocoa preparations	0	0	1	2	1	0	4
19	Cereal preparations	0	0	4	8	0	0	12
20	Fruit, vegetable and nut preparations	0	2	1	22	13	0	38
21	Other preparations	0	0	0	0	0	0	0
22	Beverages, spirits and vinegar	0	4	1	11	12	0	28
23	Residues and waste from food industry	0	0	0	0	0	2	2
Total		4	17	115	262	36	2	436

### 11.3.2. The frequency of technical measures by tariff line (HS-02) using the UNCTAD's Database

As discussed above, a second source of data on technical measures applied to agricultural and food products by the US and EU was used: the UNCTAD's database on Trade Control Measures. For both the US and EU these data are available at the HS-6 level, although for the purposes of the current analysis these were aggregated to the HS-2 level.

Table 11.11 reports the proportion of tariff lines that are subject to technical measures at the HS-2 level. This provides a broad indication of the coverage of technical measures by product type. In the case of the EU, technical measures have the greatest coverage in the case of cereals, products of the millings industries, dairy products, eggs and honey, and cereal preparations. In the US, products with the greatest coverage of technical measures are cereals, preparations of meat and fish, cereal preparations, fish, crustaceans and molluscs, dairy products, eggs and honey, live animals and fruit, vegetable and nut preparations. The coverage of technical measures across virtually all products is greater in the US than the EU.

**Table 11.11. Incidence of technical measures in European Union and United States**

HS Code	Product	% of tariff lines	
		European Union	United States
1	Live animals	17	94
2	Meat and edible meat offal	54	84
3	Fish, crustaceans, molluscs etc.	82	97
4	Dairy products, eggs and honey	71	96
5	Other products of animal origin	0	100
6	Live plants, flowers etc.	0	86
7	Edible vegetables, roots and tubers	16	98
8	Edible fruits and nuts	20	93
9	Coffee, tea and spices	0	14
10	Cereals	100	100
11	Products of the milling industries (starch, gluten etc.)	81	0
12	Oilseeds	9	41
13	Gums, resins etc.	8	17
14	Other vegetable products	0	0
15	Animal and vegetable oils and fats	9	9
16	Preparations of meat and fish	8	100
17	Sugar and sugar confectionery	68	11
18	Cocoa and cocoa preparations	0	0
19	Cereal preparations	71	100
20	Fruit, vegetable and nut preparations	18	93
21	Other preparations	6	89
22	Beverages, spirits and vinegar	16	60
23	Residues and waste from food industry	46	0
24	Tobacco and manufactured tobacco substitutes	0	0
<b>TOTAL</b>		<b>25</b>	<b>65</b>

Source: UNCTAD

Table 11.12 reports the number of technical measures applied to agricultural and food products in the US by type, as classified in the database. The predominant types of measure are testing, inspection or quarantine requirements to protect human health and product characteristic requirements for human health protection. Table 11.13 provides comparable data for the EU. The predominant types of measure, based on a different system of classification, are prior surveillance, authorisation to protect wildlife, and prohibition for human health protection. These data thus provide a very different picture to the regulatory database in terms of the objectives and types of measure applied by the US and EU. This illustrates the problems of obtaining reliable data on technical measures, given the number and various types of measure applied and lack of a consistent system of classification.

**Table 11.12. Technical measures applied to agricultural and food products in the US by type**

Type of Measure	Number of Measures
Authorisation to protect human life	27
Authorisation to protect animal health	47
Authorisation to protect plant health	322
Authorisation to protect wildlife	67
Product characteristics requirements for human health protection	829
Product characteristics requirements plant health protection	28
Product characteristics requirements to control drug abuse	4
Marking requirements	59
Marking requirements to protect human health	27
Labelling requirements	60
Labelling requirements to protect human health	27
Testing, inspection or quarantine requirements to protect human health	922
Testing, inspection or quarantine requirements to protect animal health	47
Testing, inspection or quarantine requirements to protect plant health	35
<b>Total</b>	<b>2501</b>

Source: UNCTAD

**Table 11.13. Technical measures applied to agricultural and food products in EU by type**

Type of Measure	Number of Measures
Prior surveillance	878
Non-automatic licence	4
Authorisation to protect wildlife	238
Authorisation to control drug abuse	3
Prohibition	8
Prohibition for human health protection	155
Technical requirements	3
Product characteristics requirements for human health protection	99
Labelling requirements to protect human health	100
Testing, inspection and quarantine requirements	3
<b>TOTAL</b>	<b>1494</b>

Source: UNCTAD

Tables 11.14 and 11.15 report the distribution of US and EU technical measures by tariff line at the HS-2 level. Tariff lines to which technical measures are most frequently applied in the US are dairy products, eggs and honey, fruit, vegetable and nut preparations, fish, crustaceans and molluscs, preparations of meat and fish, edible vegetables, roots and tubers, edible fruits and nuts, and other products of animal origin. In the EU, technical measures are most frequently applied to meat and edible meat offal, dairy products, eggs and honey, cereal preparations, beverages, spirits and vinegar, products of the milling industries and cereals.

**Table 11.14. Technical measures applied to agricultural and food products in the US by product**

<b>HS Code</b>	<b>Product</b>	<b>Number of Measures</b>
1	Live animals	49
2	Meat and edible meat offal	138
3	Fish, crustaceans, molluscs etc.	232
4	Dairy products, eggs and honey	522
5	Other products of animal origin	160
6	Live plants, flowers etc.	76
7	Edible vegetables, roots and tubers	200
8	Edible fruits and nuts	162
9	Coffee, tea and spices	5
10	Cereals	21
11	Products of the milling industries (starch, gluten etc.)	0
12	Oilseeds	30
13	Gums, resins etc.	0
14	Other vegetable products	0
15	Animal and vegetable oils and fats	8
16	Preparations of meat and fish	201
17	Sugar and sugar confectionery	24
18	Cocoa and cocoa preparations	0
19	Cereal preparations	146
20	Fruit, vegetable and nut preparations	340
21	Other preparations	176
22	Beverages, spirits and vinegar	119
23	Residues and waste from food industry	0
24	Tobacco and manufactured tobacco substitutes	0
<b>TOTAL</b>		<b>2501</b>

Source: UNCTAD

**Table 11.15. Technical measures applied to agricultural and food products in the EU by product**

HS Code	Product	Number of Measures
1	Live animals	55
2	Meat and edible meat offal	361
3	Fish, crustaceans, molluscs etc.	58
4	Dairy products, eggs and honey	205
5	Other products of animal origin	12
6	Live plants, flowers etc.	25
7	Edible vegetables, roots and tubers	29
8	Edible fruits and nuts	44
9	Coffee, tea and spices	0
10	Cereals	73
11	Products of the milling industries (starch, gluten etc.)	82
12	Oilseeds	8
13	Gums, resins etc.	2
14	Other vegetable products	1
15	Animal and vegetable oils and fats	29
16	Preparations of meat and fish	33
17	Sugar and sugar confectionery	30
18	Cocoa and cocoa preparations	0
19	Cereal preparations	200
20	Fruit, vegetable and nut preparations	62
21	Other preparations	9
22	Beverages, spirits and vinegar	126
23	Residues and waste from food industry	50
24	Tobacco and manufactured tobacco substitutes	0
<b>TOTAL</b>		<b>1494</b>

Source: UNCTAD

Both the regulatory database and UNCTAD data highlight a number of products to which technical measures are widely applied, in particular animal-based products. However, there are a number of inconsistencies between these two data sets. On the one hand, the UNCTAD data indicates a wider range of products to which technical measures are heavily applied. On the other, there are differences in the relative frequency of technical measures across tariff lines between the two data sets.

The discussion so far has focuses on the numbers and types of technical measures applied, with no consideration of the tariff lines that are most important in EU-US trade in agricultural and food products. In order to highlight those products for which technical measures are potentially most trade distortive, the Trade Coverage Ratio (TCR) and Frequency Index (FI) were calculated for 1999 using UNCTAD data on technical measures and COMEXT data on exports to the US. These calculations were undertaken at the HS-6 level and then aggregated to the HS-2 level. Results are reported in Table 11.16.

Of the 24 tariff lines for agricultural and food products, both the TCR and FI were 100 percent, indicating that all products are subject to technical measures. These include live animals, meat, fish,

meat and fish preparations, dairy products, fruit and vegetables, cereals and cereal preparations. Relatively few tariff lines (4) have no technical measures applied to them. Most of the remaining tariff lines have TCR and FI values exceeding 50 percent. These results suggest that technical measures are potentially an issue for most agricultural and food exports to the US. However, they do not provide any indication on their own of the tariff lines for which technical measures are most trade distortive. Furthermore, no account is taken of differences in the number of technical measures applied to each tariff line, only of whether measures are applied or not.

**Table 11.16. Trade coverage ratio and frequency index for technical measures applied to EU agricultural and food exports to the US**

<b>HS Code</b>	<b>Product</b>	<b>TCR</b>	<b>FI</b>
1	Live animals	100.0	100.0
2	Meat and edible meat offal	100.0	100.0
3	Fish, crustaceans, molluscs etc.	100.0	100.0
4	Dairy products, eggs and honey	100.0	100.0
5	Other products of animal origin	100.0	100.0
6	Live plants, flowers etc.	100.0	100.0
7	Edible vegetables, roots and tubers	100.0	100.0
8	Edible fruits and nuts	100.0	100.0
9	Coffee, tea and spices	0.21	12.9
10	Cereals	100.0	100.0
11	Products of the milling industries (starch, gluten etc.)	0.0	0.0
12	Oilseeds	60.9	45.9
13	Gums, resins etc.	54.8	9.1
14	Other vegetable products	0.0	0.0
15	Animal and vegetable oils and fats	1.2	10.5
16	Preparations of meat and fish	100.0	100.0
17	Sugar and sugar confectionery	30.2	20.0
18	Cocoa and cocoa preparations	0.0	0.0
19	Cereal preparations	100.0	100.0
20	Fruit, vegetable and nut preparations	97.8	96.1
21	Other preparations	100.0	100.0
22	Beverages, spirits and vinegar	80.5	72.2
23	Residues and waste from food industry	0.0	0.0
<b>TOTAL</b>		<b>73.5</b>	<b>70.4</b>

The foregoing discussion has provided some insight into the number and types of technical measures applied by the US and EU to agricultural and food products. However, in itself, it provides only limited indications of the products for which technical measures may actually distort trade. Thus, its key value is in guiding further analysis and aiding the interpretation of the results of the business survey reported in section 11.5.

#### 11.4. Estimation of tariff-rate equivalents

This second stage of the analysis explores the potential utility of tariff-rate equivalents to estimate the effect of technical measures on EU exports of agricultural and food products to the US. Technical measures alter relative prices between world and national markets in a similar manner to tariffs. Thus, one approach to assess the impact of technical measures is to explore the gap in relative prices where technical measures are applied.

The price wedge approach is employed below to estimate tariff-rate equivalents. Such an approach has previously been employed to assess the price effects of technical measures (see for example Calvin and Krissoff, 1998). The price wedge in this case is the difference between the US ( $P_{US}$ ) price and the price of an equivalent EU product delivered to the US, which is used as a proxy for the world price ( $P_W$ ). The aim of the price wedge approach is to account for the difference between these two prices by allocating it into the known ad-valorem tariff ( $T$ ) and the technical measure tariff-rate equivalent ( $T_{TM}$ ). The tariff-rate equivalent can thus be interpreted as the tariff rate that would restrict trade to the same level as the technical measure.

Calvin and Krissoff (1998) develop a simple partial equilibrium framework that endogenously determines the tariff-rate equivalent and level of trade:

$$P_{US} \leq P_W(1 + T + T_{TM}) \quad \text{if } T = 0 \quad (1)$$

$$P_{US} = P_W(1 + T + T_{TM}) \quad \text{if } T > 0$$

$$T = D(P_{US}) - S(P_{US}) \quad (2)$$

Where:

$T$  = Imports from all sources

$D$  = US domestic demand

$S$  = US Domestic supply

$P_{US}$  = US wholesale price

$P_W$  = World price adjusted for freight and insurance costs

$T$  = Ad-valorem tariff rate

$T_{TM}$  = Technical measure tariff-rate equivalent.

It is assumed in this framework that  $P_W$  reflects the costs of supplying a "standard" product and is not influenced by the technical measure of interest. Thus, it is assumed that the technical measure only applies and affects the flow of product aimed at the US market.

If trade takes place, then equation (1) is a strict equality and  $T_{TM}$  provides a reliable measure of the extent to which the technical measure act as a barrier to trade (Calvin and Krissoff, 1998). If trade does not take place, equation (1) is an inequality and  $T_{TM}$  is only a lower-bound estimate of the impact of the technical measure.

A number of product case studies were undertaken in an attempt to estimate tariff-rate equivalents. However, the majority of these were not successful, reflecting the inherent problems with the price wedge approach as detailed below. However, one "successful" example is provided below as illustration.

The case study described below estimates the tariff-rate equivalent of hygiene requirements for poultry meat in the US. Exporters of poultry meat to the US are subject to a system of prior inspection and approval by the US authorities to ensure compliance with US sanitary requirements. Furthermore, for some years there has been a dispute between the US and EU over the equivalency of decontamination methods in the processing of poultry. Apart from some trade in higher value breast meat, exports of poultry to the US are negligible. This case study provides some assessment of the extent to which this might be explained, at least in part, by the existence of sanitary requirements.

In order to estimate the tariff-rate equivalent of these sanitary requirements, various data is required as follows (the sources of the data employed in the analysis are given in parentheses): i) US wholesale price (USDA ERS); ii) EU wholesale price (Eurostat); iii) transport and insurance costs (USDA ERS). Combining the EU wholesale price and transport and insurance costs a CIF price for potential EU exports of poultry meat to the US can be calculated. These data refer to high value poultry meat as is typically exported by the EU.

The estimated quarterly tariff-rate equivalent for the period 1996 to 2000 is reported in Table 11.17. Over this period the tariff-rate equivalent of US sanitary requirements for poultry meat has declined significantly, from around 14 percent at the start of 1996 to around 8 percent at the end of 2000. Furthermore, the estimated tariff-rate equivalent varies on a quarterly basis reflecting changes in EU and US market prices.

Estimation of tariff-rate equivalents through the price wedge approach has a number of weaknesses, which limit its application in empirical studies. Many of these problems were experienced in the current study:

- The availability of data on wholesale market prices, freight rates and insurance costs for the products of interest is often limited. This reflects the fact that this type of analysis is often undertaken on very specific and clearly defined product categories.

- It is difficult to exactly match products sold on the US market with those exported from the EU. In some cases no equivalent products may exist, for example cheese. In others, there may be significant quality differences. Both of these factors limit the ability to make valid comparisons of relative prices.

- Other factors may influence differences in relative prices between the US and EU, for example other technical measures, differences in supply structures, etc. It may be very difficult to allow for such differences in estimating tariff-rate equivalents through the price wedge approach.

- The price wedge approach assumes that technical measures only affect the specific flows of products of interest. In the current example, exports of poultry from the EU to the US. However, technical measures may have a more wide-ranging impact depending on the strategy suppliers adopt to comply with such requirements.

For all of the above reasons, it was not possible to apply the price wedge approach more widely in the current study.

**Table 11.17. Tariff-rate equivalent for EU poultry meat exports to the US**

<b>Year</b>	<b>Quarter</b>	<b>US Wholesale Price (cents/lb)</b>	<b>EU Price (cents/lb)</b>	<b>Tariff (cents/lb)</b>	<b>Transport Costs (cents/lb)</b>	<b>EU CIF Price (cents/lb)</b>	<b>Difference (cents/lb)</b>	<b>Tariff Rate Equivalent (%)</b>
1996	1	92	69.2	3.9	5.8	78.9	13.3	14.4
	2	84	67.3	3.9	6	77.2	11.9	13.4
	3	90.2	68.4	3.9	5.9	78.2	12	13.3
	4	99.4	69.2	3.9	5.4	78.5	11.9	13.2
1997	1	88.1	68.9	3.9	5.5	78.3	6.8	8.0
	2	73.7	65.4	3.9	6.2	75.5	4.6	5.7
	3	82.1	63.5	3.9	5.9	73.3	8.8	10.7
	4	91	67.6	3.9	6.7	78.2	6.1	7.2
1998	1	56.4	63.8	3.9	7.4	75.1	9.5	11.2
	2	61.05	57.4	3.9	7.1	68.4	7.2	9.5
	3	70.39	58.4	3.9	6.7	69	5.3	7.1
	4	64.2	53.1	3.9	6	63	5.2	7.6
1999	1	58.11	51.6	3.9	6.2	61.7	5.4	8.0
	2	58.47	48.6	3.9	6.8	59.3	4.9	7.6
	3	58.08	46.9	3.9	7.2	58	4.3	6.9
	4	57.6	46.2	3.9	7.4	57.5	2.3	3.8
2000	1	54.58	43.3	3.9	7.3	54.5	2.7	4.7
	2	55.54	42.6	3.9	7.5	54	2.3	4.1
	3	58.02	44.6	3.9	7.4	55.9	5.3	7.7
	4	57.12	43.2	3.9	7.3	54.4	5.2	8.7

## **11.5. Estimation of costs of compliance with technical requirements**

### ***11.5.1. Theoretical basis***

The focus of this paragraph is the compliance cost approach, aiming to present a framework that will facilitate estimation of the additional costs of compliance for exporters that are associated with technical barriers to trade. Costs of compliance can be defined as:

The additional costs necessarily incurred by businesses in meeting the requirements laid upon them in complying with a given regulation.

There are two key elements to this definition. Firstly, it covers the costs that are "additional" to those which would have been incurred in the absence of the regulation. Secondly, it refers to those costs that are "necessarily" incurred when complying with the regulation. These are discussed in greater detail below.

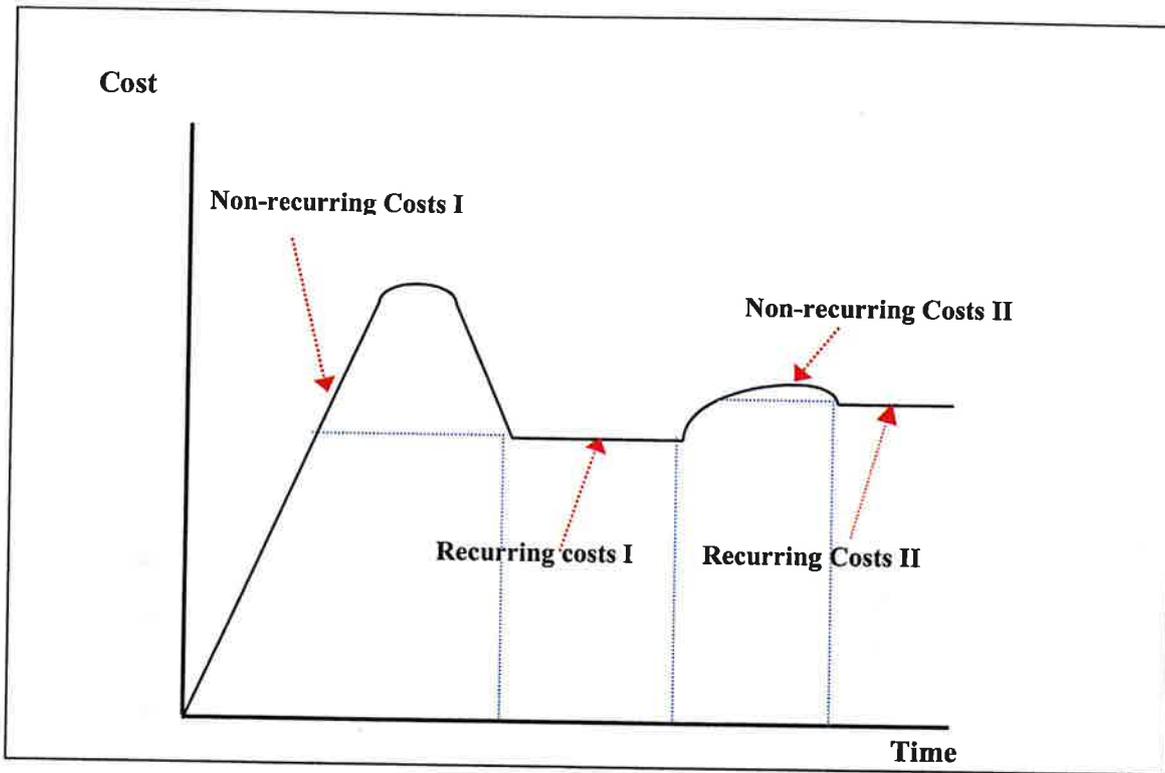
A distinction can be drawn between direct and indirect costs of compliance. Direct costs are associated with the primary purpose of technical standards and/or conformity assessment procedures, whereas indirect costs result from effects not directly related to the purpose of these requirements. For example, the direct costs of compliance with a requirement to include particular information on a product label might include label redesign. The indirect costs might include product reformulation in response to the requirement to label the product in this manner.

Compliance costs can be further sub-divided into non-recurring and recurring costs of compliance (Figure 11.13). Non-recurring costs refer to one-off items of expenditure that are required for initial compliance, for example investment in new capital. Recurring costs are associated with more permanent increases in operating expenditures, for example product testing requirements. The distinction between recurring and non-recurring costs suggests that account must be taken of the stage in the compliance process that costs are measured. Further, it is generally accepted that recurring and non-recurring costs can impede trade in a somewhat different manner (Henson, 1997).

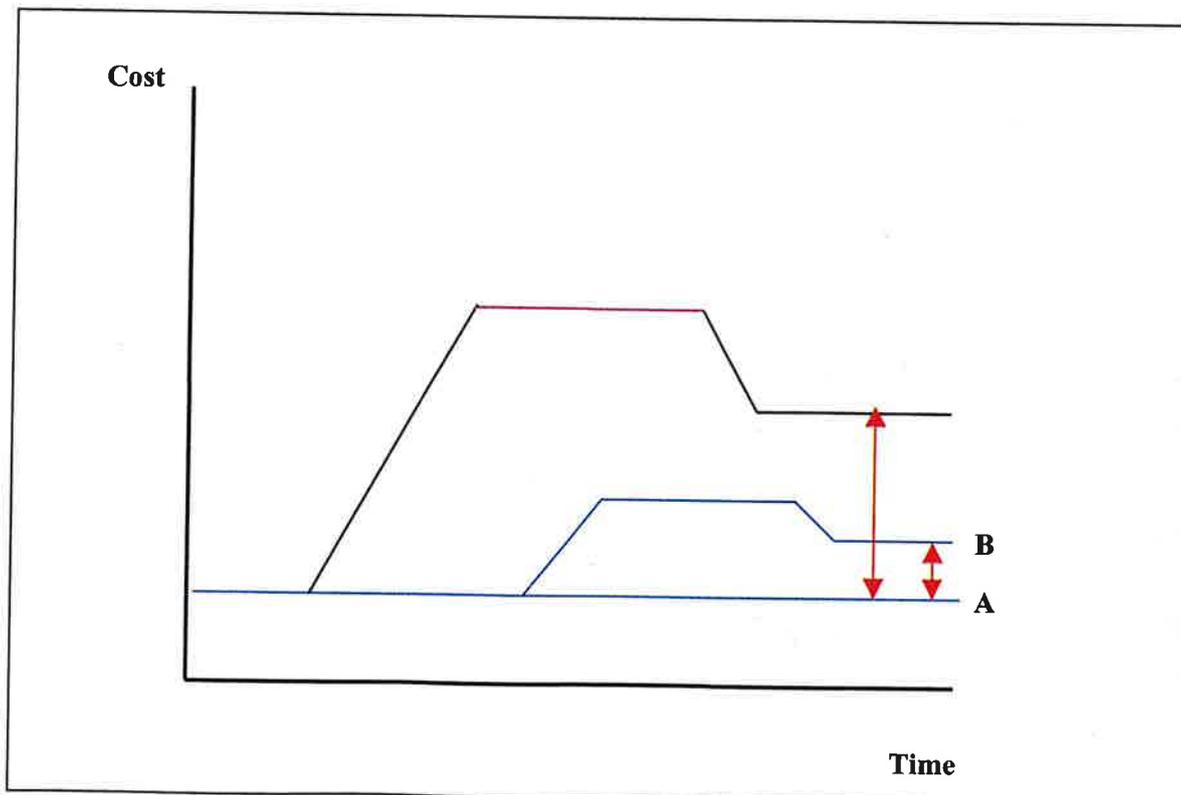
In order to estimate the "additional" costs that are imposed on a supplier as a direct result of a technical measure, an appropriate benchmark must be defined. The aim of this is to identify the changes in supply practices that have come about as a direct result of the measure. The easiest approach is to compare the supply practices adopted by suppliers consequent upon the imposition of the measure to those that were previously or would otherwise be applied (A in Figure 11.14). In this case of an exporter, for example, the technical requirements in the home market and/or alternative export markets may be used as a baseline. However, this assumes that the firm would not have adapted their supply practices in the absence of the measures (B in Figure 11.14) and provide an unreliable

assessment of changes in supply practices that are directly attributable to the introduction of the measure and, in turn, compliance costs.

**Figure 11.13. Compliance cost profile**



**Figure 11.14. Benchmark for the measurement of costs of compliance**



Both of these stages will involve costs associated with compliance with the standard and with specified conformity assessment procedures. Stage one of this process is associated with non-recurring costs of compliance - one-off expenditure required to achieve compliance with the standard and thus facilitate entry to the market. This will determine the ability and/or willingness of exporters to comply with the specified standards and supply the export market. Stage two is associated with recurring costs of compliance - additional production and other supply costs required to supply product that is in

conformity assessment procedures;

- production and supply of the product complying with the specified standard and compliance with

specified standard;

- adaptation of the production processes and/or the final product to facilitate compliance with the

of two stages (Henson, 1997):

The process which suppliers follow in order to comply with technical requirements typically consists

needed to estimate costs of compliance at the firm level.

economic, physical, geographical and policy environment in which they operate. This reinforces the individual suppliers, some of which relate to the characteristics of the supplier itself and others to the compliance, whatever this might be? A number of factors will influence the compliance efficiency of imperfect information, or should they be measured on the basis of the most efficient method of should be measured on the basis of what firms actually do, given prevailing market forces and requirements in the most cost-effective manner. This raises the question of whether compliance costs Finally, compliance costs will depend on the extent to which firms comply with technical

requirement to include certain information?

have otherwise made such changes, or simply the additional cost of the label redesign due to the this case should the cost of compliance be the total cost of the label redesign since the firm would not requirement to include certain information on a product label to redesign their entire product label. In changes that may not be directly required to achieve compliance. For example, firms may utilise a many instances, firms utilise the changes required to comply with technical standards to institute other the "unavoidable" or "necessary" costs of compliance from "avoidable" costs can be problematic. In costs should be included since they remain a product of the regulation (Henson, 1997). Disentangling voluntary, they should be excluded from compliance costs, whilst others suggest even discretionary There is some debate about how to handle avoidable costs. Some suggest that since avoidable costs are whilst avoidable costs are those costs which businesses choose to incur in the process of compliance, those necessarily incurred if the business is to meet legal requirements specified in an export market, avoidable (voluntary or discretionary) compliance costs (Sandford et al, 1989). Unavoidable costs are In measuring costs of compliance a distinction can be made between unavoidable (mandatory) and

compliance and to demonstrate compliance has been achieved. This will determine the extent to which exporters that are able to comply face barriers to trade that increase their costs over and above those of domestic suppliers.

In the case of non-recurring costs of compliance, the framework involves the comparison of fixed costs associated with adapting the product and/or production process to facilitate compliance. Thus, it requires a measure of the net additional non-recurring costs of compliance that exporters face, over and above those of domestic suppliers ( $NC_X^F$ ):

$$NC_X^F = C_X^F - C_D^F$$

Where:

$NC_X^F$  = Net additional non-recurring costs of compliance for exporters;

$C_X^F$  = Non-recurring costs of compliance for exporters;

$C_D^F$  = Non-recurring costs of compliance for domestic suppliers.

Whilst this does not provide a measure of the extent to which the measure acts as a barrier to trade, it does indicate the additional investments that exporters are required to make in order to gain access to the market concerned.

The degree to which a technical measure acts as barrier to trade depends on the net additional recurring costs of compliance imposed on exporters ( $NC_X^V$ ). This can be computed in a similar way to above, by comparing the costs imposed on domestic suppliers and exporters:

$$NC_X^V = C_X^V - C_D^V$$

Where:

$NC_X^V$  = Net additional recurring costs of compliance for exporters;

$C_X^V$  = Recurring costs of compliance for exporters;

$C_D^V$  = Recurring costs of compliance for domestic suppliers.

It is also possible to derive an index of relative recurring costs of compliance ( $I_V$ ):

$$I_V = [C_X^V / C_D^V] - 1$$

which has a value of 0 when  $C_X^V = C_D^V$  and is increasing as the net additional recurring costs of compliance faced by exporters increase. This enables the relative recurring costs of domestic suppliers and individual exporters to be compared with ease and provides a convenient ranking of the extent to which the measure act as a barrier to trade.

Food and agricultural products are typically subject to a range of technical barriers to trade. An assumption of this framework is that the effects of individual technical measures can be separated out from one another and aggregated to provide an overall measure of the net additional costs of compliance faced by exporters. In turn, this assumes that there is no synergy in compliance with a range of technical requirements simultaneously, meaning the overall cost of compliance is less than the sum of the costs associated with individual measures.

A further assumption is that domestic suppliers and/or exporters do not yield a price premium from compliance with the technical measure, either directly because suppliers value the fact that the product meets legal requirements or indirectly because the overall quality of the product is enhanced. Whilst this may be a more valid assumption for basic food commodities, in the case of more highly processed and value-added food products it may be violated. However, in this case it is an easy task to adapt the framework to incorporate the relative price premia received by domestic suppliers and exporters.

#### *11.5.2. Survey of EU agricultural and food exporters*

In order to assess the problems and the costs associated with compliance with technical requirements for agricultural and food products in the United States, a survey was undertaken of EU exporters. A sample of 1,800 exporters of agricultural and food products were selected from across six Member States: Belgium, France, Germany, Italy, Netherlands and United Kingdom. An equal number of exporters (300) was selected from each Member State. These Member States were selected because a directory of agricultural and food exporters was available. They include most of the major exporters of agricultural and food in the EU; the notable exclusion is Spain.

The survey was undertaken during the period April to July 2000. The sampled exporters were sent the questionnaire and after a period of two weeks a reminder was mailed. Respondents were offered a summary of the survey results as an incentive.

##### *11.5.2.1. Nature of respondents*

Table 11.18 details the response rate from each of the selected Member States. The overall number of valid responses was 330, a rate of 18 percent. There were, however, significant differences in the response rate across the Member States, from 6.1 percent in the case of Belgium to 27.0 percent in the case of Germany (cf. Table 11.18).

**Table 11.18. Number of respondents by Member State**

Member State	Number
Belgium	20 (6.1%)
France	30 (9.1%)
Germany	89 (27.0%)
Italy	86 (26.1%)
Netherlands	35 (10.6%)
United Kingdom	70 (21.2%)
Total	330

*11.5.2.2. Main characteristics of respondents*

The majority of respondents were relatively small companies. Almost 50 percent of respondents had less than 50 employees (Table 11.19) and almost 65 percent only operated one processing plant (Table 11.20). Around 50 percent had a turnover of €14 million or less (Figure 11.15). However, a significant, although relatively small, proportion of larger exporters responded to the survey. These companies had 500 or more employees, operated three or more plants, and had a turnover exceeding €180 million. This profile broadly corresponds with the structure of the agricultural and food processing sector in the EU.

**Table 11.19. Number of respondents by number of employees**

Number of Employees	Number
Less 10	57 (17.3%)
10-49	102 (30.9%)
50-99	37 (11.2%)
100-499	79 (23.9%)
500-999	16 (4.8%)
1,000 or more	31 (9.4%)
Total	330

**Table 11.20. Number of respondents by number of plants operated**

Number of Employees	Number
1	189 (64.5%)
2	29 (9.9%)
3	33 (11.3%)
4	15 (5.1%)
5 or more	21 (7.1%)

**Figure 11.15. Decile distribution of respondents by turnover**

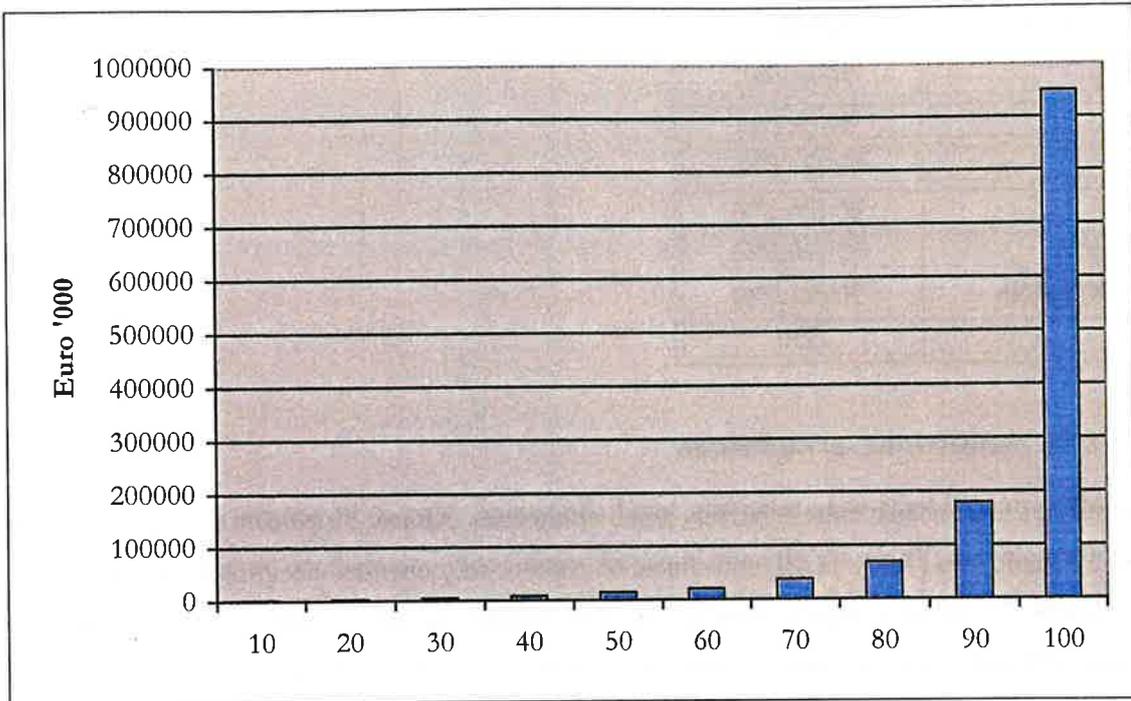


Figure 11.16 details the agricultural and food products exported by respondents. In many cases each company exported more than one product type. Products most frequently exported by respondents were confectionery, biscuits and cakes, dairy products, meat products, and fruit, vegetable and nut products. Consequently, the survey provides the most information, as well as the most reliable information, on problems encountered exporting these products.

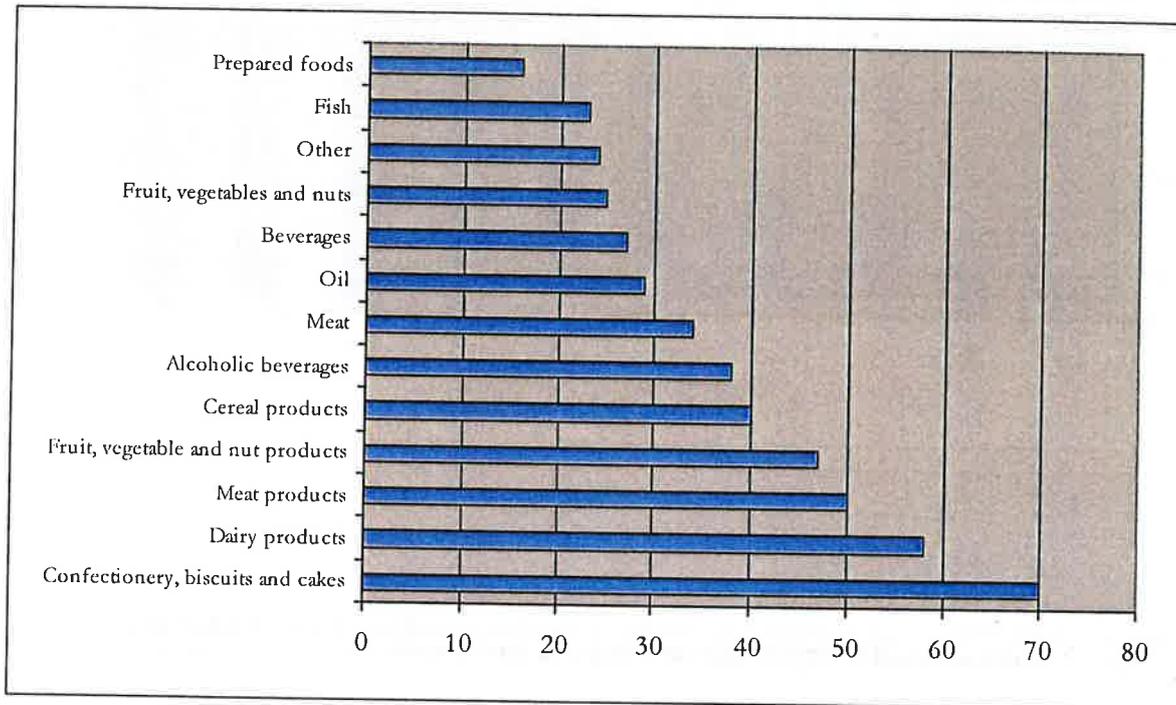
For the majority of respondents, exports to non-EU countries accounted for less than 50 percent of total exports (Figure 11.17). Indeed, for almost 50 percent, non-EU exports accounted for less than 10 percent of total exports. Non-EU exports accounted for 50 percent or more of total exports for only 15 percent of respondents.

Figure 11.18 reports the contribution of exports to the US to total non-EU exports. Whilst the US was the sole export market for very few of the respondents, it accounted for 35 percent or more of non-EU exports for more than 50 percent of respondents. This suggests that US exports are an important market for the majority of respondents.

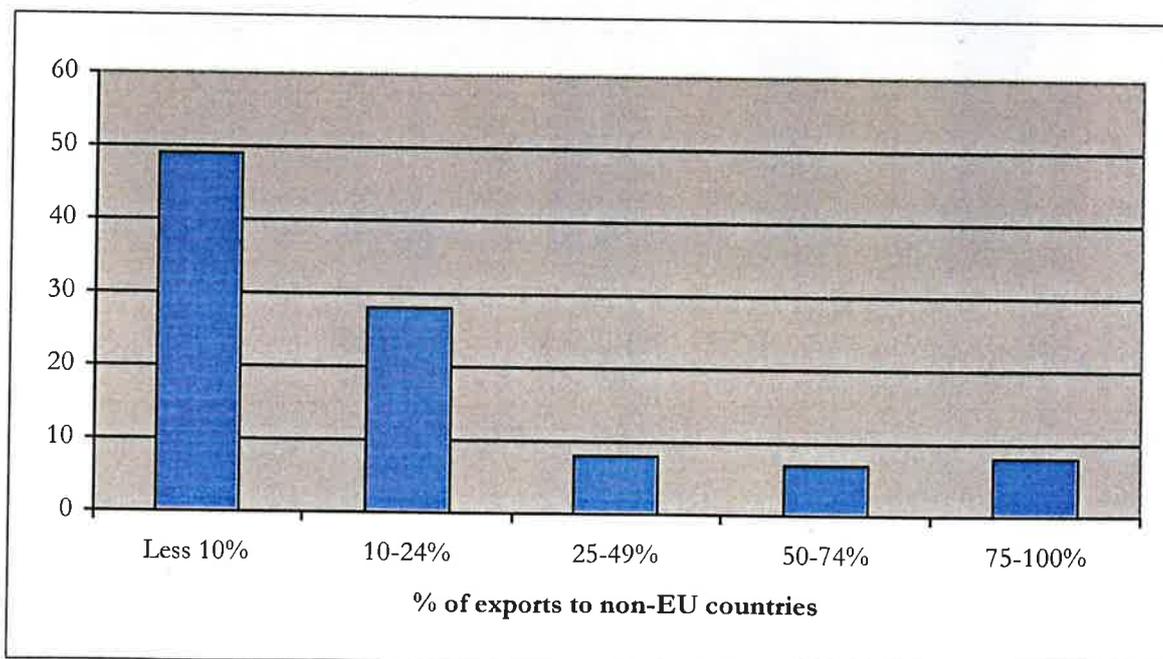
It was evident from in-depth interviews prior to the survey that the nature of the supply chain has a significant bearing on the knowledge of exporters regarding regulatory and other requirements. Specifically, exporters that have direct contacts with buyers typically have a greater knowledge of technical requirements and of the problems associated with compliance than those that supply, for example, via an export agent. Figure 11.19 reports the methods used to export agricultural and food

products to the US by respondents. Over 60 percent of respondents exported through direct contact with a US buyer. This suggests that the majority were likely to have a good knowledge of technical requirements in the US.

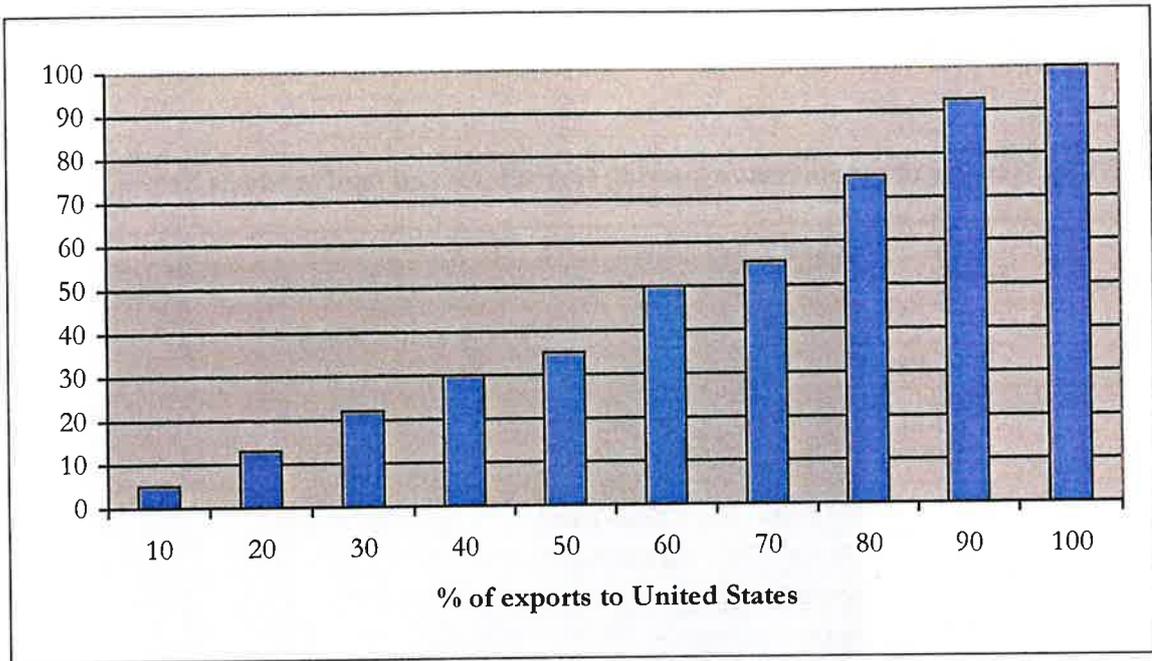
**Figure 11.16. Number of respondents exporting agricultural and food products by product**



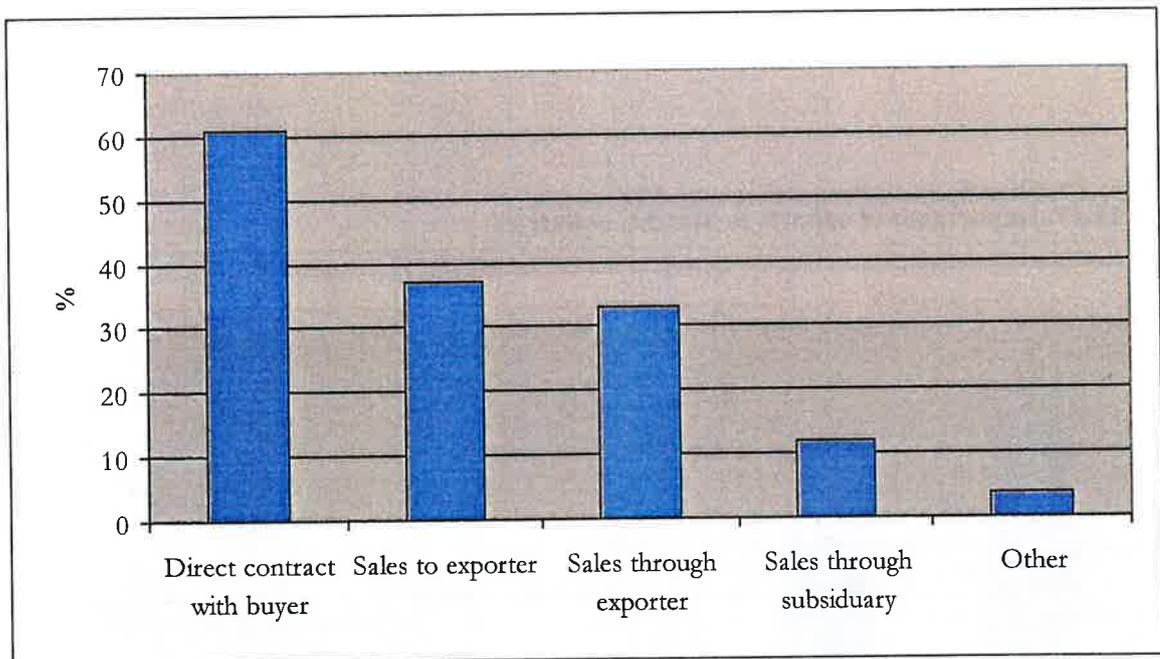
**Figure 11.17. Importance of exports to non-EU countries**



**Figure 11.18. Decile distribution of respondents exporting to the US by percentage of non-EU exports**



**Figure 11.19. Methods used to export agricultural and food products to the United States**



### 11.5.3. Survey results: Problems exporting agricultural and food products to the US

#### 11.5.3.1. The importance of technical requirements relative to other factors influencing exports to the US

The first stage of the questionnaire aimed to assess the importance of technical requirements relative to other factors influencing agricultural and food exports to the US. Respondents were asked to score a series of factors that might influence their ability to export to the US on a five-point Likert scale, from "very important" (1) at one extreme to "very unimportant" (5) at the other. Table 11.21 shows that the factors ranked first were market price and general labelling requirements. The factors ranked second were consumer demand, customer requirements and nutritional labelling requirements. Food safety and legal product quality requirements were ranked third. These results suggest that technical requirements, and in particular labelling requirements, were judged to be major factors influencing the ability of EU exporters to export agricultural and food products to the US.

**Table 11.21. Mean importance score for factors influencing ability to export to the US**

Factor	Mean Score
Market price	1.52 <sup>a</sup>
General labelling requirements	1.56 <sup>a</sup>
Consumer demand	1.78 <sup>b</sup>
Customer requirements	1.81 <sup>b</sup>
Nutrition labelling requirements	1.84 <sup>b</sup>
Food safety requirements	1.96 <sup>c</sup>
Legal product quality requirements	1.99 <sup>c</sup>
Distribution system	2.11 <sup>d</sup>
US trade restrictions	2.13 <sup>d</sup>
Export refunds	2.95
Other	3.32

Note: Scores denoted by same letter are not significantly different at the 5% level.

The mean importance score for the 11 factors in Table 11.21 provides an overall measure of the problems experienced exporting agricultural and food products to the US. Table 11.22 reports the mean importance score disaggregated according to main products exported. These results suggest that the products for which the greatest problems are experienced exporting to the US are meat, meat products and prepared foods. Fish, confectionery, biscuits and cakes, and fruit, vegetables and nuts are ranked second in terms of the overall problems experienced exporting to the US.

**Table 11.22. Mean importance score disaggregated according to main products exported**

<b>Product</b>	<b>Mean Score</b>
Meat	1.63 <sup>a</sup>
Meat products	1.65 <sup>a</sup>
Prepared foods	1.67 <sup>a</sup>
Fish	1.81 <sup>b</sup>
Confectionery, biscuits and cakes	1.82 <sup>b</sup>
Fruit, vegetables and nuts	1.82 <sup>b</sup>
Fruit, vegetable and nut products	1.93 <sup>c</sup>
Dairy products and eggs	1.95 <sup>c</sup>
Alcohol	2.14
Cereals products	2.38
Other	2.96
Oil	3.00 <sup>d</sup>
Beverages	3.02 <sup>d</sup>
All products	2.09

Table 11.23 below reports the mean importance score for technical requirements disaggregated according to the main product exported. These results suggest that the importance of food safety, labelling and legal product quality requirements in terms of the ability to export to the US differs widely between products. The products for which each of these technical requirements were considered most important were as follows:

- **Food safety requirements:** dairy products and eggs, fruit, vegetables and nuts, prepared foods.
- **General labelling requirements:** oil, alcohol, meat products, fruits, vegetables and nuts.
- **Nutrition labelling requirements:** prepared foods, oil, confectionery, biscuits and cakes, beverages.
- **Legal product quality requirements:** Fish, fruit, vegetables and nuts, beverages, fruit, vegetable and nut products.

This suggests that it may be difficult to draw general conclusions about the impact of technical measures on exports of agricultural and food products as a whole. Rather, specific product types need to be considered on a case-by-case basis.

To this regard, Table 11.24 reports the mean importance score for the four types of technical requirement disaggregated according to main products exported. Results suggest that the products for

which technical requirements are the greatest problem are oil, fruit, vegetable and nuts, fish, dairy products and eggs, and prepared foods.

However, the importance of individual measures within this overall score differs (as discussed above). Thus, for example, whilst technical measures are most important for the ability to export oil, legal product quality requirements are less important than for many other food products (Table 11.23 and Figure 11.20). Similarly, whilst technical requirements as a whole are relatively unimportant in terms of the ability to export alcohol to the US, general product labelling requirements are more important than for most other agricultural and food products (Table 11.23 and Figure 11.20). This reiterates the need to consider the impact of technical requirements on a product-by-product basis.

**Table 11.23. Mean importance score for technical requirements disaggregated according to the main product exported**

Product	Mean Score			
	Food Safety Requirements	General Labelling Requirements	Nutrition Labelling Requirements	Legal Product Quality Requirements
Meat	1.89	2.02	1.99 <sup>d</sup>	2.31
Meat products	1.63 <sup>b</sup>	1.36 <sup>a</sup>	2.00 <sup>d</sup>	1.98 <sup>c</sup>
Dairy products and eggs	1.37	1.68 <sup>b</sup>	1.79 <sup>c</sup>	1.91
Fruit, vegetables and nuts	1.50 <sup>a</sup>	1.60	2.02 <sup>d</sup>	1.45 <sup>a</sup>
Fruit, vegetable and nut products	1.79	1.71 <sup>b</sup>	1.78 <sup>c</sup>	1.67
Cereals products	2.03 <sup>c</sup>	1.81	1.68 <sup>b</sup>	2.10
Confectionery, biscuits and cakes	2.07 <sup>c</sup>	1.68 <sup>b</sup>	1.59 <sup>a</sup>	1.80 <sup>b</sup>
Alcohol	2.35	1.34 <sup>a</sup>	1.71 <sup>b</sup>	1.77 <sup>b</sup>
Fish	1.70	1.90 <sup>c</sup>	1.70 <sup>b</sup>	1.42 <sup>a</sup>
Prepared foods	1.50 <sup>a</sup>	1.69 <sup>b</sup>	1.43	2.18 <sup>d</sup>
Oil	1.61 <sup>b</sup>	1.33 <sup>a</sup>	1.52	2.00 <sup>c</sup>
Beverages	2.12	1.70 <sup>b</sup>	1.60 <sup>a</sup>	1.56
Other	2.21	1.90 <sup>c</sup>	2.50	2.21 <sup>d</sup>
All products	1.96	1.56	1.84	1.99 <sup>c</sup>

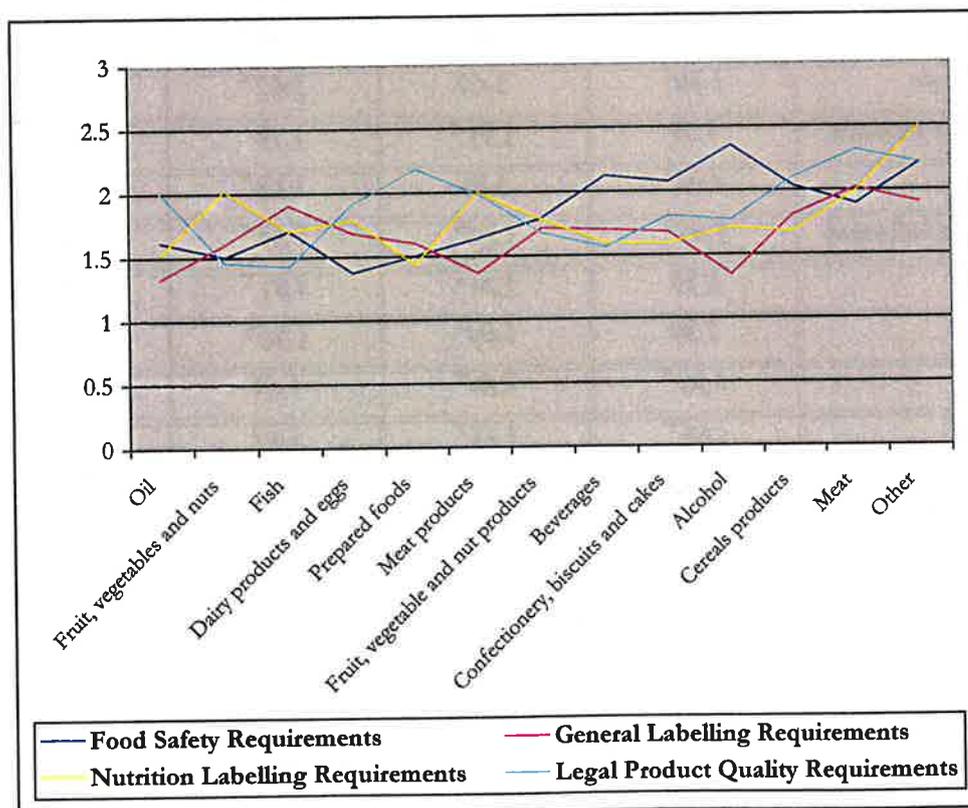
Note: In each column, scores with same letter are not significantly different at the 5% level.

**Table 11.24. Mean importance score for the four types of technical requirement disaggregated according to main products exported**

Product	Mean Score
Oil	1.62 <sup>a</sup>
Fruit, vegetables and nuts	1.63 <sup>a</sup>
Fish	1.69 <sup>b</sup>
Dairy products and eggs	1.70 <sup>b</sup>
Prepared foods	1.70 <sup>b</sup>
Meat products	1.76 <sup>c</sup>
Fruit, vegetable and nut products	1.76 <sup>c</sup>
Beverages	1.77 <sup>c</sup>
Confectionery, biscuits and cakes	1.78 <sup>c</sup>
Alcohol	1.79 <sup>c</sup>
Cereals products	1.91
Meat	2.05
Other	2.21
All products	1.84

Note: Scores with same letter are not significantly different at the 5% level.

**Figure 11.20. Mean importance of technical measures to ability to export to the US, by product in order of increasing ability**



*11.5.3.2. The importance of technical requirements in the US relative to other export markets*

The importance of technical requirements in the ability to export agricultural and food products also differs between export markets. Respondents were asked to score the importance of the four technical requirements discussed above on a five-point Likert scale from "very important" (1) at one extreme to "very unimportant" (5) at the other, as regards to exports in various countries. Tables 11.25 to 11.28 indicate that globally the countries for which these requirements were considered most important in terms of the ability to export agricultural and food products were the United States, Canada and Japan.

**Table 11.25. Mean importance of food safety requirements on ability to export to various regions**

Region	Food Safety Requirements
Canada	1.88
United States	1.92
Japan	2.03 <sup>a</sup>
Other EU countries	2.07 <sup>a</sup>
Australia/New Zealand	2.07 <sup>a</sup>
Middle East	2.21 <sup>b</sup>
Asia	2.21 <sup>b</sup>
Eastern Europe	2.22 <sup>b</sup>
South America	2.32
Africa	2.47 <sup>c</sup>
Russia	2.50 <sup>c</sup>

Note: Scores with same letter are not significantly different at the 5% level.

**Table 11.26. Mean importance of product labelling requirements on ability to export to various regions**

Region	Product Labelling Requirements
United States	1.70
Canada	1.80
Japan	1.99
Middle East	2.09 <sup>a</sup>
Australia/New Zealand	2.09 <sup>a</sup>
Asia	2.11 <sup>a</sup>
Other EU countries	2.12 <sup>a</sup>
Eastern Europe	2.21 <sup>b</sup>
South America	2.24 <sup>b</sup>
Russia	2.37 <sup>c</sup>
Africa	2.38 <sup>c</sup>

**Table 11.27. Mean importance of legal product quality requirements on ability to export to various regions**

<b>Region</b>	<b>Legal Product Quality Requirements</b>
United States	1.97 <sup>a</sup>
Canada	2.02 <sup>a</sup>
Japan	2.11
Australia/New Zealand	2.19 <sup>b</sup>
Other EU countries	2.22 <sup>b</sup>
Eastern Europe	2.29 <sup>b</sup>
Asia	2.31 <sup>b</sup>
Middle East	2.39
South America	2.49 <sup>b</sup>
Russia	2.52 <sup>b</sup>
Africa	2.52 <sup>b</sup>

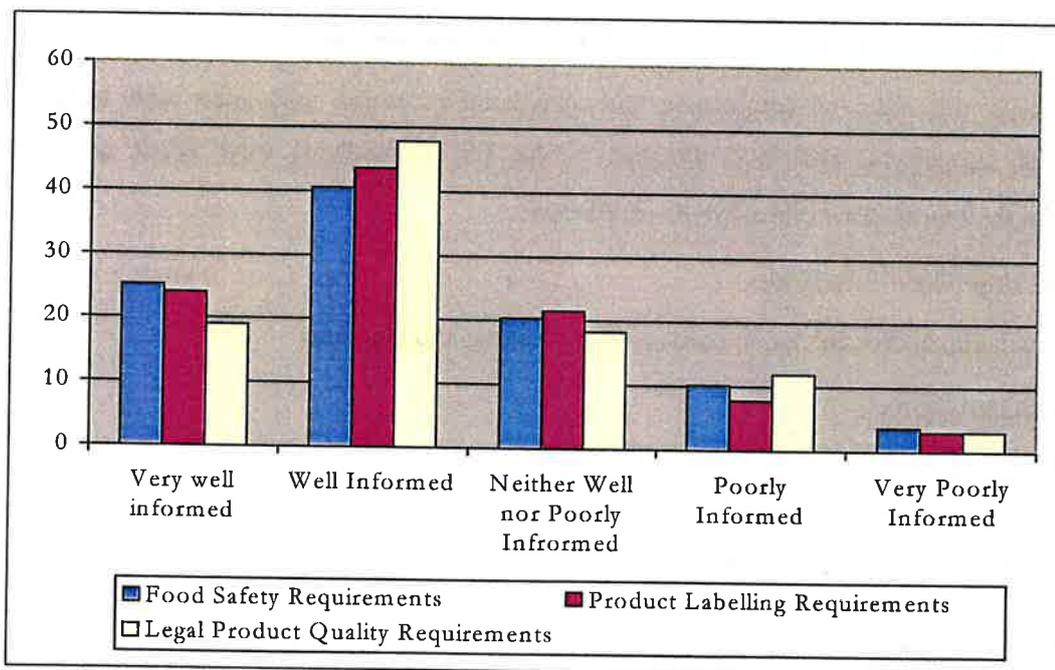
**Table 11.28. Mean importance of general labelling requirements on ability to export to various regions**

<b>Region</b>	<b>General Labelling Requirements</b>
United States	1.88 <sup>a</sup>
Canada	1.88 <sup>a</sup>
Japan	2.04
Australia/New Zealand	2.12 <sup>b</sup>
Other EU countries	2.14 <sup>b</sup>
Asia	2.23 <sup>c</sup>
Middle East	2.24 <sup>c</sup>
Eastern Europe	2.25 <sup>c</sup>
South America	2.35
Africa	2.46 <sup>d</sup>
Russia	2.49 <sup>d</sup>

### 11.5.3.3. The awareness of exporters about US technical requirements

An important factor influencing the impact of technical requirements on the ability to export agricultural and food products is the level of awareness of exporters about the requirements with which they must comply. Respondents were asked to indicate the degree to which they were informed about technical requirements on a five-point Likert scale from "very well informed" (1) at one extreme to "very poorly informed" (5) at the other. In general, over 60 percent of respondents considered they were informed about the technical requirements for agricultural and food products in the United States (Figure 11.21). The mean awareness score, however, was greatest for product labelling requirements (2.22), followed by food safety requirements (2.27), and lowest for legal product quality requirements (2.32).

**Figure 11.21. Degree to which informed about technical requirements for agricultural and food products in the United States**



Respondents were then asked to indicate the importance of a variety of potential sources of information on technical requirements for agricultural and food products in the US on a five-point Likert scale from "very important" (1) at one extreme to "very unimportant" (5) at the other. The most important sources of information were export agents and customers in the US (Table 11.29). Relatively unimportant sources were their own government, trade organisations in the US and consultants.

**Table 11.29. Sources of information on technical requirements for agricultural and food products in the United States**

Source	Mean Importance Scale
Export agents	1.50
Customers in United States	1.73
Subsidiary in United States	2.24 <sup>a</sup>
Trade organisations in own country	2.24 <sup>a</sup>
Own government	2.43 <sup>b</sup>
Trade organisations in United States	2.47 <sup>b</sup>
Consultants	2.83
Other	3.05

Note: Scores with same letter are not significantly different at the 5% level.

#### *11.5.4. Survey results: costs of compliance with US technical requirements*

In order to assess the costs of compliance and associated problems associated with technical requirements for agricultural and food products in the US, respondents were asked questions separately about the four stages of the compliance process:

- prior approval of production facilities;
- product reformulation and/or change in production, packaging and labelling;
- impact on production costs;
- border procedures.

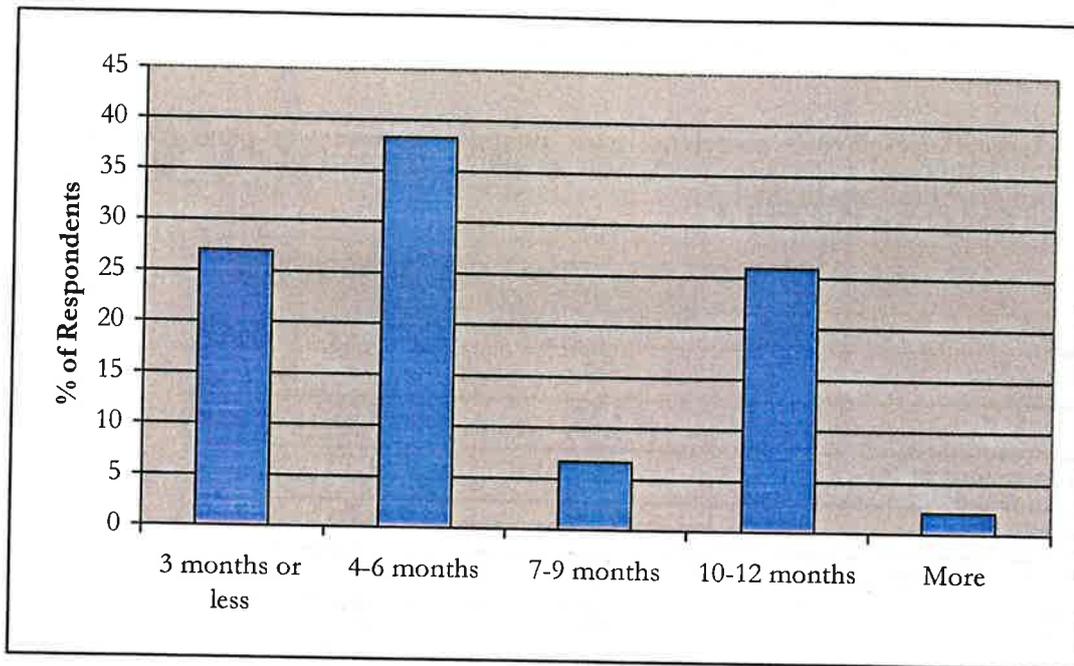
Each of these will now be considered in turn.

##### *11.5.4.1. Prior approval of production facilities*

Only 34 percent of respondents were required to obtain approval of their production facilities prior to commencing exports to the US. These were mainly exporters of meat and meat products, dairy products and eggs and low acid canned foods. Of these, 81 percent were required to make changes to their processing facilities.

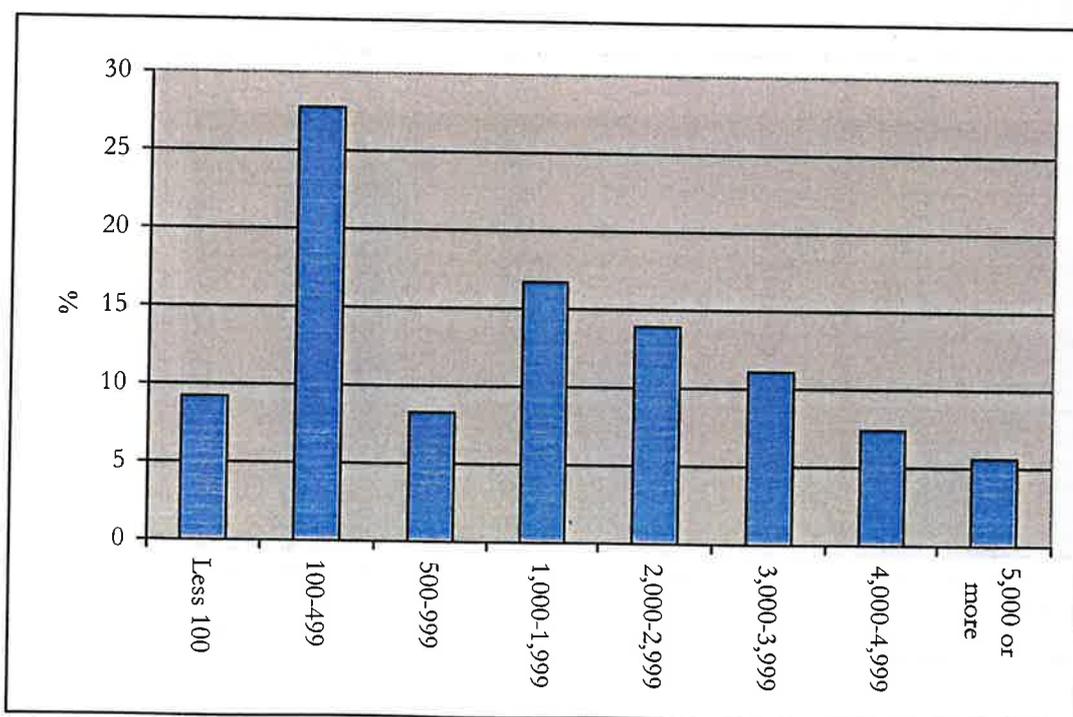
Figure 11.22 reports the time taken by respondents to obtain approval of their production facilities prior to commencing exports to the US. For around 60 percent of respondents, the time taken to obtain approval was less than six months. However, for around 30 percent of respondents this process had taken 10 months or more.

**Figure 11.22. Time taken to obtain approval of plant for export to the United States**



In addition to the costs associated with the time taken to obtain approval, in terms of the value of lost exports, respondents were asked to estimate the cost of the changes required to obtain approval of their processing facilities. The mean cost was €1.2 million, but varied from less than €100,000 to € 5 million or more (Figure 11.23). The mean cost of obtain plant approval accounted for 0.56 percent of turnover and 4.2 percent of the value of annual exports to the US.

**Figure 11.23. Cost of adapting plant for approval to export agricultural and food products to the US (euro '000)**



Respondents were asked to indicate the importance of a range of potential costs of obtaining approval of their production facilities on a five-point Likert scale from "very important" (1) to "very unimportant" (5). The most important costs were changes to documentation, upgrading of structure of plant, and changes to procurement of raw materials (Table 11.30).

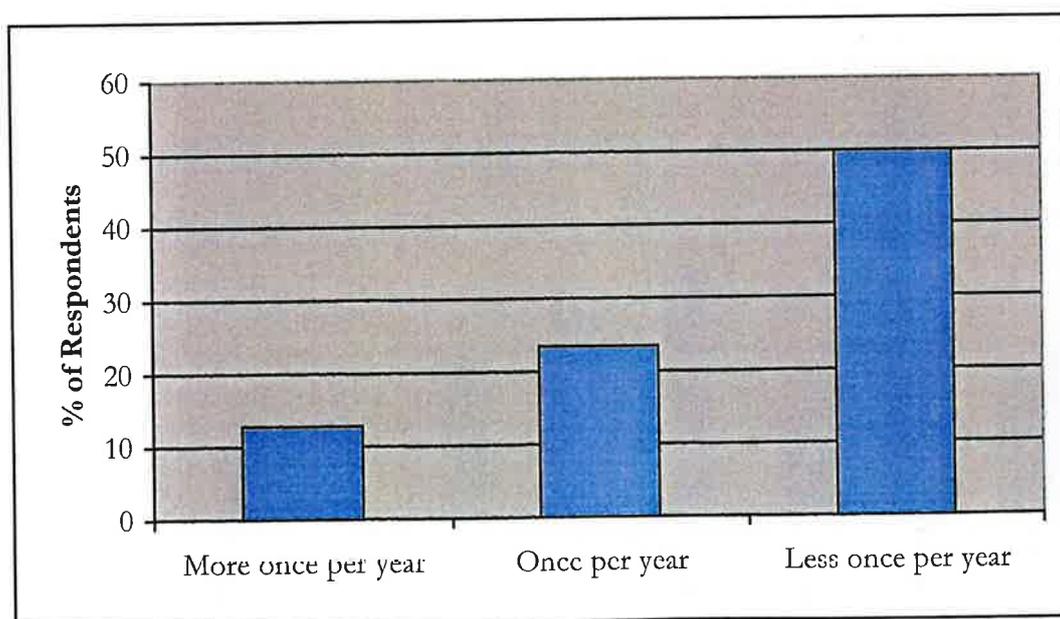
**Table 11.30. Importance of costs associated with obtaining approval of plant for export of agricultural and food products to the US**

Cost	% not Incurring Cost	Mean Importance Score
Documentation	8.5	1.57
Structure of plant	12.8	1.72 <sup>a</sup>
Raw material procurement	14.0	1.72 <sup>a</sup>
Processing equipment	11.8	1.86 <sup>b</sup>
Quality assurance/control procedures	7.4	1.87 <sup>b</sup>
Product storage	16.8	2.21
Other	81.9	2.38

Note: Scores with same letter are not significantly different at the 5% level.

Of those respondents that had been required to obtain prior approval of their production facilities, 79 percent had been inspected by US and/or EU/national authorities. Furthermore, these facilities were typically subject to re-inspection on a periodic basis, although for the majority this was undertaken less than once per annum (Figure 11.24).

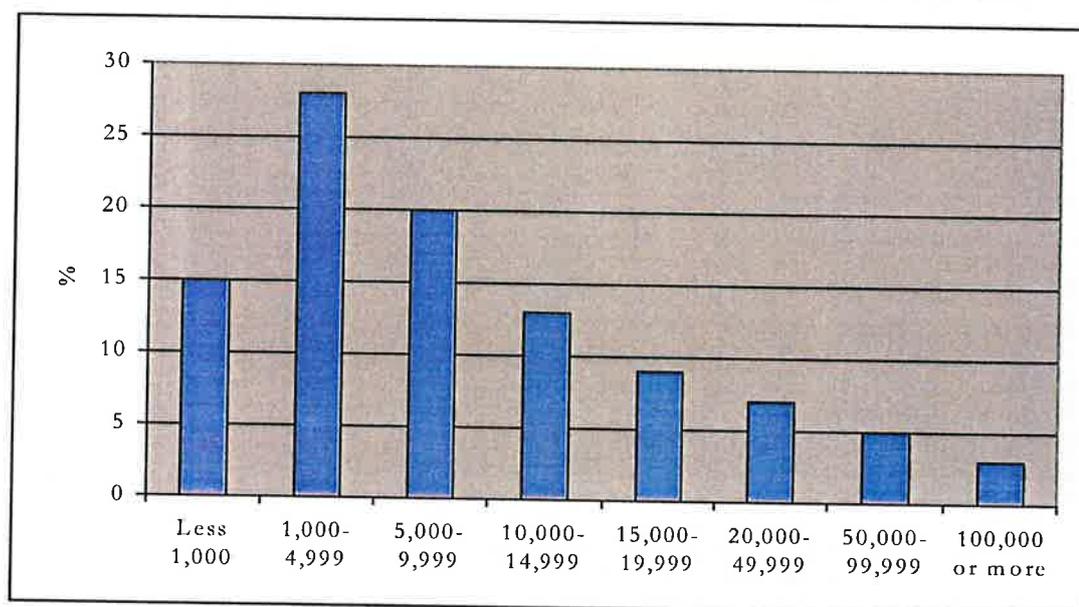
**Figure 11.24. Frequency of inspection of plant for approval to export agricultural and food products to the US**



#### 11.5.4.2. Product reformulation and/or change in production, packaging and labelling

Almost 50 percent (161) of respondents had been required to reformulate their product to comply with US technical requirements. The costs associated with product reformulation ranged from less than €1,000 to €100,000 or more, with a mean of €12,100 (Figure 11.25).

**Figure 11.25. Cost of adapting product and/or manner in which it is produced, packaged or labelled for export to the US**



Respondents were asked to indicate the importance of a range of potential costs of product reformulation on a five-point Likert scale from "very important" (1) at one extreme to "very unimportant" (5) at the other. The costs that were of greatest importance were changes to product ingredients, changes to product labels and revision of quality assurance processes (Table 11.31).

**Table 11.31. Importance of costs associated with reformulating product and/or manner in which it is produced, packaged or labelled for export to the United States**

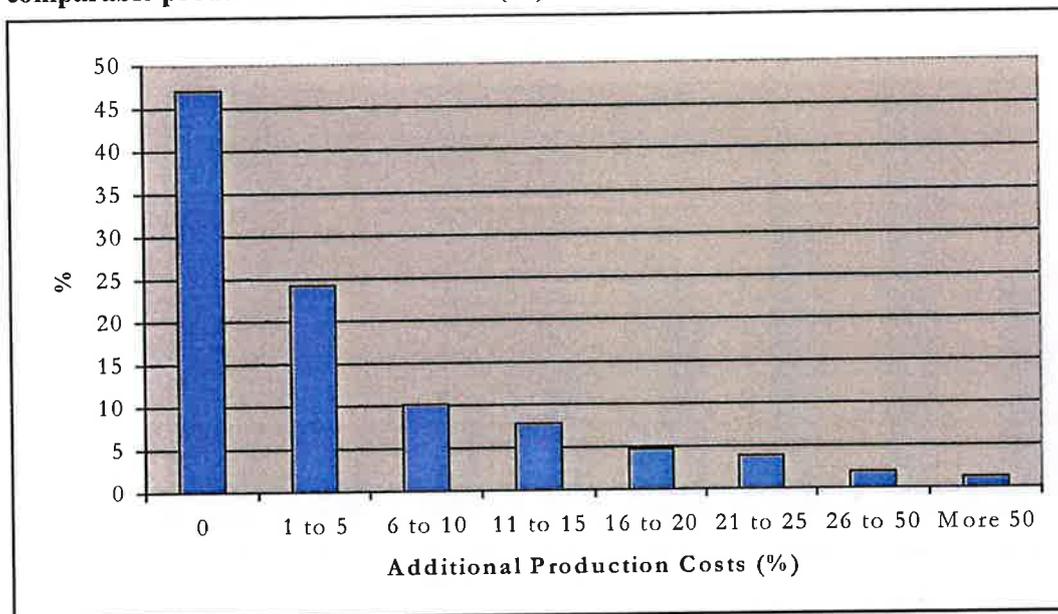
Cost	% not Incurring Cost	Mean Importance Score
Product ingredients	25.9	1.80 <sup>a</sup>
Product label	5.6	1.81 <sup>a</sup>
Quality assurance process	23.8	1.91
Quality of raw materials	23.8	1.99 <sup>b</sup>
Packaging	5.2	2.01 <sup>b</sup>
Product testing	22.0	2.12 <sup>c</sup>
Method of processing	24.7	2.14 <sup>c</sup>
Product storage	28.6	2.29
Other	38.7	3.42

Note: Scores with same letter are not significantly different at the 5% level.

#### 11.5.4.3. Impact on production costs

Around 56 percent of respondents indicated that the cost of producing a product for export to the US was greater than producing an equivalent product for sale within the EU (Figure 11.26). The mean additional cost of producing for export to the US was 4.2 percent, although around 30 percent of respondents indicated that additional production costs exceeded five percent.

**Figure 11.26. Additional costs of producing product for export to the US compared to comparable product for sale in the EU (%)**



Respondents were asked to indicate the importance of a range of potential additional costs of producing for export to the US on a five-point Likert scale from "very important" (1) at one extreme to "very unimportant" (5) at the other. The most important additional costs of producing for export to the US were additional input costs, and the costs of certification and quality control/assurance (Table 11.32).

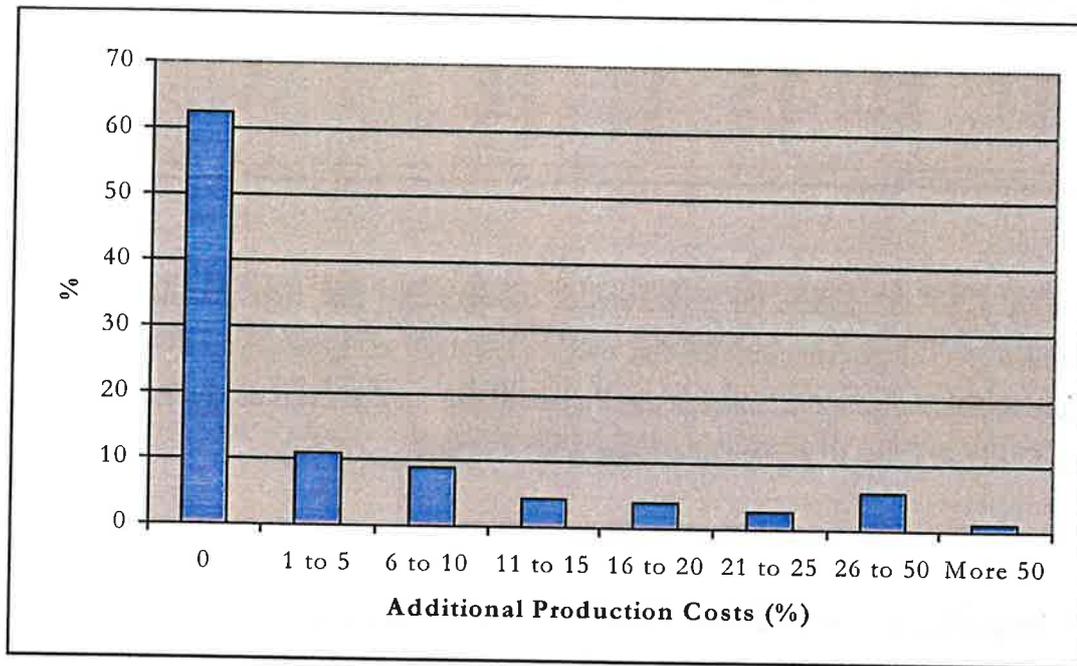
**Table 11.32. Importance of additional costs of production compared to equivalent product for sale in the EU**

Cost	% not Incurring Cost	Mean Importance Score
Cost of inputs	30.6	1.62
Certification	17.9	1.73 <sup>a</sup>
Quality control/assurance	19.4	1.76 <sup>a</sup>
Nutritional labelling	12.4	1.91 <sup>b</sup>
Microbiological testing	18.6	1.93 <sup>b</sup>
Other testing	22.4	1.94 <sup>b</sup>
Storage	22.1	2.09 <sup>c</sup>
Processing	20.6	2.10 <sup>c</sup>
General labelling	6.6	2.11 <sup>c</sup>
Other	42.9	2.35

Note: Scores with same letter are not significantly different at the 5% level.

Respondents were also asked to estimate the degree to which their costs of production exceeded those of an equivalent product manufactured domestically in the US. This better reflects the degree to which additional costs are imposed on EU exporters compared to US domestic suppliers. Around 37 percent of respondents indicated that their production costs exceeded those of a comparable US product. The mean additional costs were 3.1 percent, although around 25 percent indicated that their production costs were more than 5 percent higher (Figure 11.27).

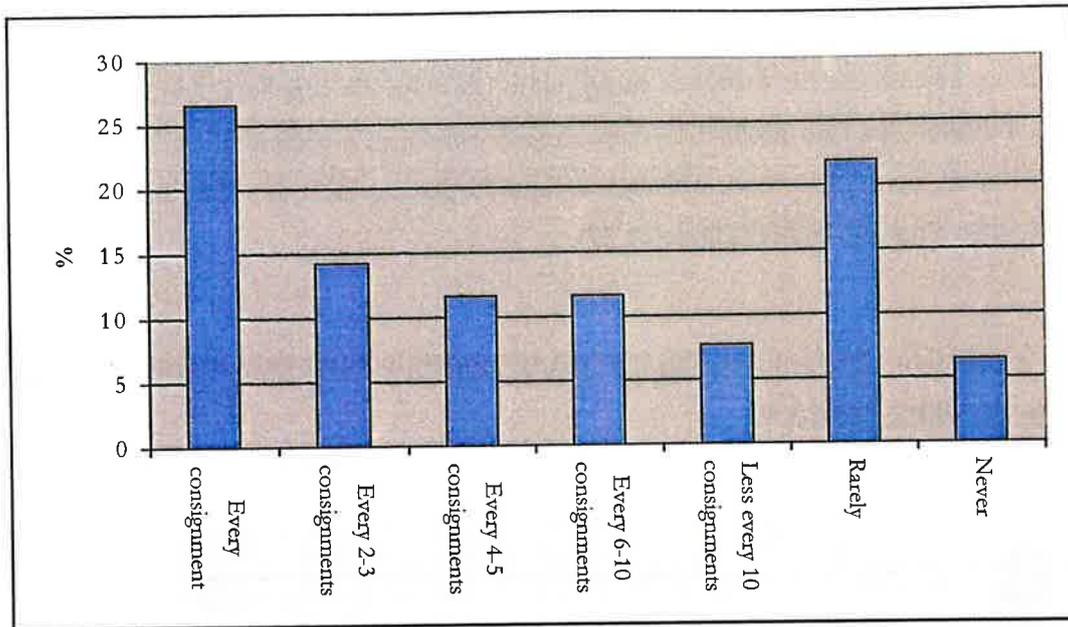
**Figure 11.27. Additional costs of producing product compared to equivalent product produced domestically in the United States (%)**



#### 11.5.4.4. Border procedures

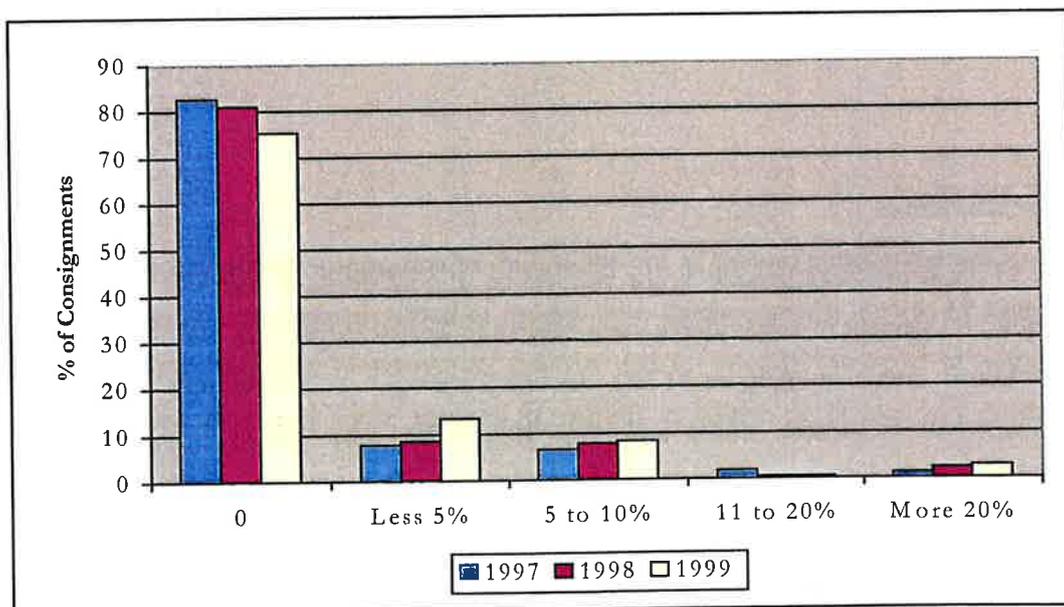
The final stage of the compliance process is the application of conformity assessment procedures at the border. Around 93 percent of respondents were subject to border inspection, although there was significant variation in frequency (Figure 11.28). Around 27 percent of respondents indicated that every consignment was inspected, whilst a further 38 percent were inspected every 2 to 10 consignments.

**Figure 11.28. Frequency of inspection at US border**



Respondents were asked to estimate the proportion of consignments that were detained following inspection. Around 75 to 80 percent indicated that, over the last three years, no consignments had been detained (Figure 11.29). Furthermore, amongst those who had had consignments detained, only around five percent had had more than 10 percent of consignments detained.

**Figure 11.29. Proportion of consignments detained following border inspection**



Respondents were also asked to indicate the destination of product consignments that had been detained. On average, around 55 percent of consignments were re-inspected and allowed to enter, whilst a further 17.5 percent were modified, re-inspected and allowed to enter (Table 11.33). On average, only around 18 percent of consignments were destroyed or re-exported. These results, with those above, suggest border inspection is generally not a problem for EU exporters of agricultural and food products.

**Table 11.33. Treatment of detained consignments**

Treatment of Detained Consignments	Mean %
Re-exported	14.7
Destroyed	12.9
Re-inspected and allowed to enter	54.7
Modified, re-inspected and allowed to enter	17.5

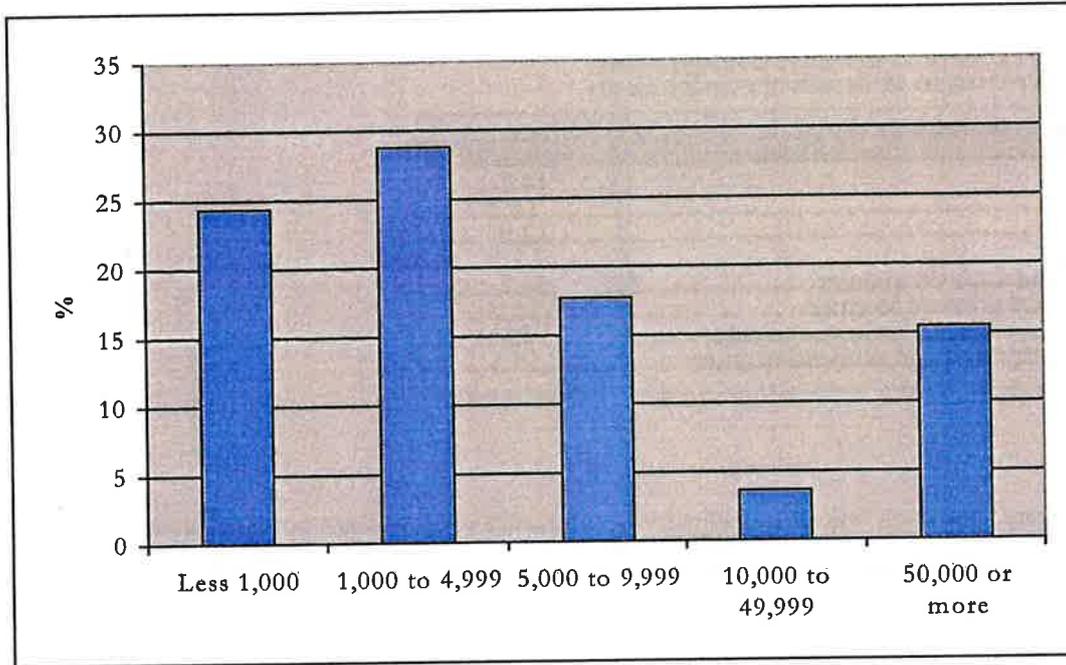
Respondents were, however, asked to indicate the importance of various potential costs associated with detention of consignments on a five-point Likert scale from "very important" (1) at one extreme to "very unimportant" (5) at the other. Costs that were considered most important were product reformulation and freight (Table 11.34).

**Table 11.34. Mean importance of costs associated with detained consignments**

Cost	Mean Importance
Product modification	1.91
Freight	2.06
Storage	2.15 <sup>a</sup>
Product testing	2.16 <sup>a</sup>
Fee to inspection agencies	2.34
Other	2.46

Respondents were also asked to estimate the average cost of a detained consignment. Around 55 percent indicated that the costs was less than €5,000, although around 20 percent indicated the cost typically exceeded €10,000 (Figure 11.30). Presumably, the magnitude of these costs is highly correlated with the size of the consignment and the perishability of the product concerned.

**Figure 11.30. Cost associated with detained consignments**



As a check on the results of the survey, respondents were asked to indicate the overall importance of costs of compliance with food safety, labelling and legal product quality requirements for the competitiveness of their products compared to those produced domestically in the US. Over 55 percent of respondents indicated that these costs were important, whilst only 12 percent indicated that they were unimportant (Figure 11.31).

**Figure 11.31. Overall importance of costs of compliance with food safety, labelling and food quality requirements for competitiveness of products compared to domestically-produced products in the US**

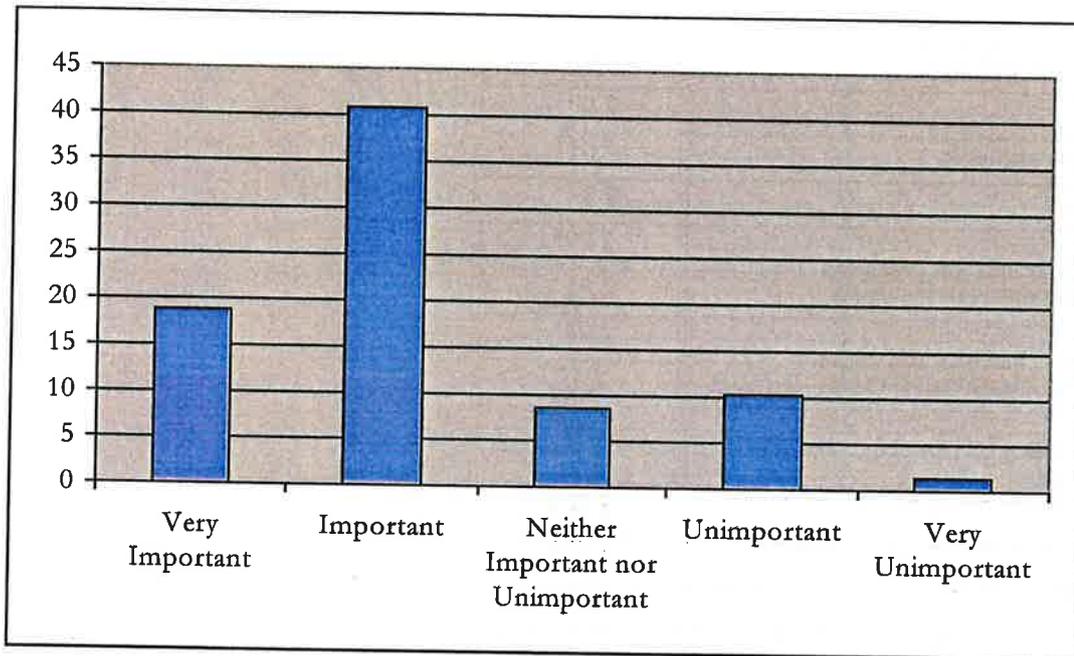


Table 11.35 disaggregates the importance of costs of compliance according to the main product exported. Products for which costs of compliance were most important were oil, fruit, vegetables and nuts, fish and dairy products and eggs. These results broadly concur with those presented in the paragraph 11.5.3.

**Table 11.35. Mean importance of costs of compliance with food safety, labelling and food quality requirements for competitiveness of products compared to competitive products in the US**

<b>Product</b>	<b>Mean Importance</b>
Oil	1.83 <sup>a</sup>
Fruit, vegetables and nuts	1.86 <sup>a</sup>
Fish	2.00 <sup>b</sup>
Dairy products and eggs	2.01 <sup>b</sup>
Prepared foods	2.03 <sup>b</sup>
Meat products	2.29 <sup>c</sup>
Fruit, vegetable and nut products	2.31 <sup>c</sup>
Beverages	2.32 <sup>c</sup>
Confectionery, biscuits and cakes	2.47
Alcohol	2.65
Cereal products	3.21
Meat	3.40 <sup>d</sup>
Other	3.42 <sup>d</sup>
All products	2.83

Note: Scores with same letter are not significantly different at the 5% level.

### **11.6. Analysis of US detentions of agricultural and food exports from the EU**

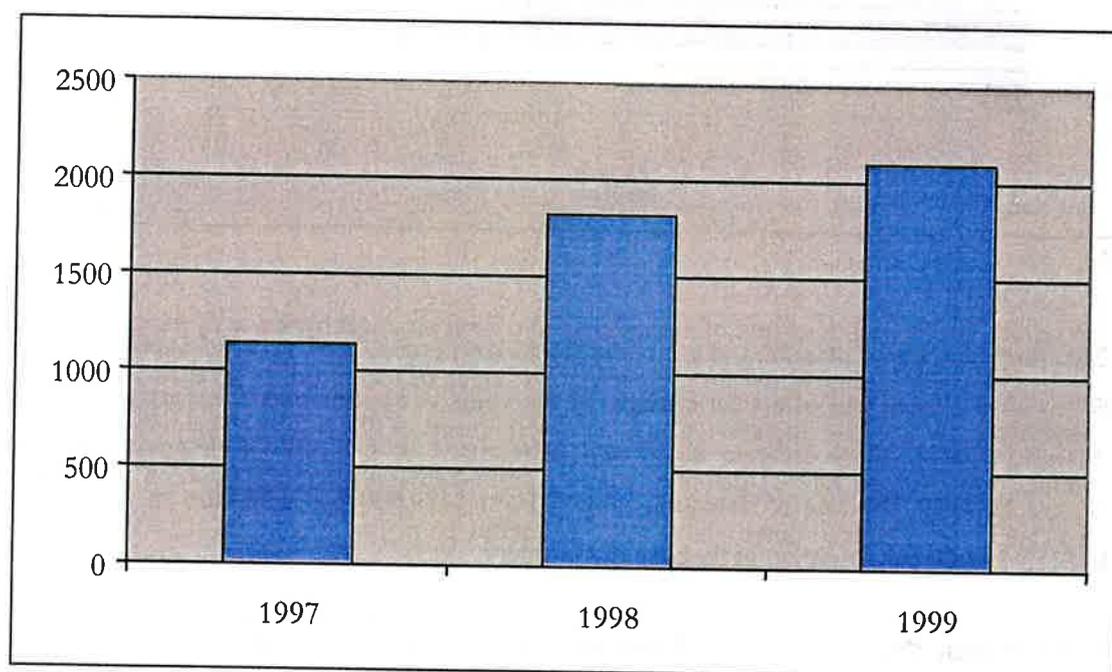
The last phase of analysis aims to identify those products for which problems are actually experienced due to technical measures. The US Food and Drugs Administration (FDA) publishes data on border detentions of products for which it is responsible. These include food and agricultural products with some exceptions:

- meat and poultry and meat and poultry products;
- animal products subject to controls relating to animal health and diseases;
- plant products subject to controls relating to plant pests and diseases.

These data do, however, provide some indication of the problems experienced by EU exporters, both in terms of those food and agricultural products most subject to detention and the reasons for detention. They do not, however, indicate the eventual destination of the products, that is whether they are eventually released and imported to the US, re-exported or destroyed.

Figure 11.32 reports the total number of US border detentions of food and agricultural product exports from the EU in 1997, 1998 and 1999. Over this period, the total number of consignments detained at the US border increased by 79 percent, whilst the value of agricultural and food exports increased by 14 percent. This suggests that the proportion of consignments that were subject to detention increased significantly over this period. Indeed, assuming the average size of consignment remained constant from 1997 to 1999, the proportion of consignments subject to detention increased by around 65 percent.

**Figure 11.32. Total US border detentions of food and drink products from the EU 1997-99**

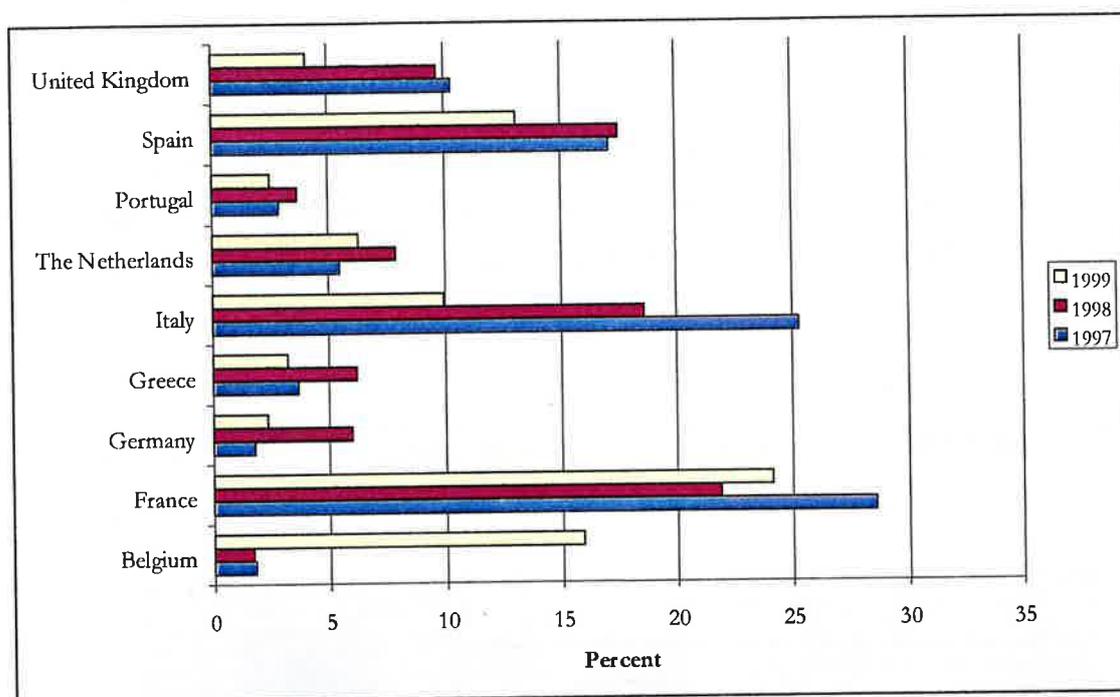


Source: FDA

Figure 11.33 reports the number of detentions by Member State over the period 1997 to 1999. Differences in levels of detention reflect both the volume of exports and the types of product being exported. In 1997 and 1998, Spain, Italy and France accounted for the vast majority of detentions. France, for example, is one of the largest exporters of agricultural and food products to the US and also exports certain "sensitive" products, such as unpasteurised cheeses. The pattern of detentions was significantly different, however, in 1999. This was due to the detection of dioxin contamination in

animal feedstuffs in Belgium, which lead to significant increases in the number of detentions of Belgian exports.

**Figure 11.33. US Border detentions of food and agricultural products from the EU by Member State, 1997-99**



Source: FDA

Table 11.36 reports the rate of detention of agricultural and food products by value of exports over the period 1997 to 1999. These data allow for changes in the value of exports over time and differences between Member States. They indicate significant differences in the rate of detention between Member States. In 1999, the rate of detention ranged from \$489,000 per detention in the case of Belgium to \$15,635,000 per detention in the case of Germany.

These data also indicate that the increase in detentions of EU exports of agricultural and food products over the period 1997 to 1999 is chiefly due to an increase in the rate of detention of exports from a small number of Member States, namely, France, Portugal, Netherlands and Belgium. In contrast the rate of detention from some Member States actually declined over this period, namely UK, Italy, Greece and Germany.

Table 11.37 reports the number of detentions of EU exports of agricultural and food products by HS-2 line. The products most subject to detention over the period 1997 to 1999 were dairy products, eggs and honey, edible vegetables, roots and tubers, fruit and nut preparations and other preparations. In 1999, cereal preparations were also subject to high rates of detentions, in response to the detection of dioxin contamination in Belgium. This reflects the importance of these products within overall

agricultural and food exports from the EU and also the number and nature of technical measures to which these products are subject.

**Table 11.36. Mean value of agricultural and food exports per US detention by EU Member State, 1997-99 (\$000)**

Member State	1997	1998	1999
United Kingdom	3649	3096	7167
Spain	2911	1974	2703
Portugal	2005	1206	1421
Netherlands	18512	9264	9615
Italy	4838	4211	6972
Greece	2817	1034	3593
Germany	11740	7781	15635
France	4957	3356	3196
Belgium	10792	7005	489

**Table 11.37. US border detentions of food and agricultural products from the EU by product, 1997-99**

HS Code	Product	Number of Detentions		
		1997	1998	1999
1	Live animals	0		0
2	Meat and edible meat offal	1	1	10
3	Fish, crustaceans, molluscs etc.	192	269	76
4	Dairy products, eggs and honey	298	349	350
5	Other products of animal origin	0	0	0
6	Live plants, flowers etc.	0	0	0
7	Edible vegetables, roots and tubers	137	400	285
8	Edible fruits and nuts	25	40	22
9	Coffee, tea and spices	30	119	68
10	Cereals	2	24	3
11	Products of the milling industries (starch, gluten etc.)	0	0	11
12	Oilseeds	0	0	
13	Gums, resins etc.	0	0	1
14	Other vegetable products	0	0	
15	Animal and vegetable oils and fats	14	10	17
16	Preparations of meat and fish	2	3	84
17	Sugar and sugar confectionery	11	28	28
18	Cocoa and cocoa preparations	35	0	21
19	Cereal preparations	59	131	594
20	Fruit, vegetable and nut preparations	219	299	246
21	Other preparations	108	122	220
22	Beverages, spirits and vinegar	5	14	2
23	Residues and waste from food industry	0	4	2
24	Tobacco and manufactured tobacco substitutes	0	0	0
<b>TOTAL</b>		<b>1138</b>	<b>1820</b>	<b>2095</b>

Source: FDA

Table 11.38 reports the reason for detention of EU exports of agricultural and food products over the period 1997 to 1999. Note that a number of reasons may be given for the detention of any consignment and, consequently, the aggregate of these figures is greater than the overall number of detentions. Throughout this period, the single most important reason for detention was no-compliance with pre-registration and/or approval procedures, in particular relating to information on methods of processing and low-acid canned foods. Non-compliance with labelling requirements and microbiological contamination were also frequent reasons for detention. In 1999, chemical contamination accounted for around 30 percent of the reasons for detention, reflecting protective measures against dioxins as a result of the detection of contamination in Belgium.

**Table 11.38. US border detentions of food and agricultural products by reason, 1997-99**

Reason	Number of Detentions		
	1997	1998	1999
Prior registration/approval			
Low acid canned food	170	302	351
Milk or cream	0	2	1
Information on process not filed	280	497	528
<i>Sub-total</i>	<i>450</i>	<i>801</i>	<i>880</i>
Chemical contamination			
Aflatoxins	0	0	2
Dioxins	0	0	544
Coumarin	0	0	1
Excess Sulfites	0	3	0
Contains fluorocarbons	0	1	1
Pesticides	28	40	98
Unsafe Colour	1	0	0
Unsafe substance	0	3	0
<i>Sub-total</i>	<i>29</i>	<i>47</i>	<i>646</i>
Labelling			
Added colours	5	3	3
Nutritional labelling	63	97	121
Flavourings	0	1	3
Dietary claim without nutrition label	1	3	3
Lacks adequate directions for use	0	0	3
Imitation products without adequate labelling	0	1	3
Inconspicuous labelling	0	13	39
Usual/common name	10	30	21
Percentage juice label	0	1	1
Placement, form or content of label	15	75	49
Name of supplier	34	30	17
Label not in English	41	46	59
Ingredients list	13	46	53
Quantity of contents	29	42	7
Preservatives	1	5	2
Preservatives	1	5	2
<i>Sub-total</i>	<i>212</i>	<i>394</i>	<i>388</i>
<i>Sub-total</i>	<i>212</i>	<i>394</i>	<i>388</i>

Reason	Number of Detentions		
	1997	1998	1999
<b>Microbiological contamination</b>			
Listeria	281	376	287
Salmonella	30	20	54
Shigella	2	0	0
Bacterial contamination	1	1	12
<i>Sub-total</i>	<i>314</i>	<i>397</i>	<i>353</i>
<b>Hygiene</b>			
Product of diseased animal	1	0	4
Filthy	51	44	50
Foreign Objects	5	4	6
Non-compliance with HACCP requirements	0	0	9
Prepared, stored or held under unsanitary conditions	0	6	22
Inadequate acidity	3	24	7
Off Odour	0	1	0
Poisonous	9	5	23
Inadequate processing	3	7	24
BSE	0	0	9
<i>Sub-total</i>	<i>72</i>	<i>91</i>	<i>154</i>
<b>Packaging</b>			
Container with non-permitted substance	0	3	6
Can with non-permitted substances	0	1	18
Leaking or swollen packaging	2	3	1
Soaked/Wet	3	3	1
<i>Sub-total:</i>	<i>5</i>	<i>10</i>	<i>26</i>
<b>Composition:</b>			
Quality standard	1	2	1
Substitution of ingredients	0	1	1
Identity standard	0	1	2
Wrong name	0	1	4
<i>Sub-total</i>	<i>1</i>	<i>5</i>	<i>8</i>
<b>Other</b>			
Unauthorised re-imported prescribed drug	0	0	1
Not listed	0	0	14
<i>Sub-total:</i>	<i>0</i>	<i>0</i>	<i>14</i>
<b>Total</b>	<b>1138</b>	<b>1820</b>	<b>2095</b>

Source: FDA.

### 11.7. Conclusions and policy recommendations

The foregoing discussion has explored a number of analyses aimed at assessing the impact of technical measures on EU exports of agricultural and food products to the US. Whilst the results of this analysis are not compatible and/or presented in a form that can be readily applied to other elements of the project, they do provide a rather in-depth assessment of the impact of technical measures. The key conclusions of the analysis are as follows:

- i) Technical measures are widely applied to EU exports of agricultural and food products to the US. Furthermore, many products are simultaneously subject to a range of technical requirements. However, whilst frequency-based measures provide some indication of potential "problem" products,

they do not indicate the manner and degree to which technical measures actually impede trade. Furthermore, whilst technical measures may impede trade, they may be justified in terms of specified policy objectives and thus cannot be defined as 'barriers' to trade.

ii) There are significant differences in the number of types of technical measures applied to agricultural and food products in the US and EU. However, there are close similarities in the products for which technical measures are most frequently and most widely applied. These include meat and edible meat offals, dairy products, eggs and honey, fish, crustaceans and molluscs, cereals, cereal preparations, edible vegetables, roots and tubers, edible fruits and nuts, and fruit, vegetable and nut preparations.

iii) A number of products are subject to relatively high rates of detention at the US border, indicating real problems complying with US technical requirements. These include fish, crustaceans and molluscs, dairy products, eggs and honey, edible vegetables, roots and tubers, fruit, vegetable and nut preparations and other preparations. Furthermore, the majority of detentions occur with exports from particular Member States, most notably France, Italy, Spain and the United Kingdom. The predominant reason for detention is non-compliance with prior approval/registration requirements.

iv) Tariff-rate equivalents, whilst a theoretically attractive approach to estimate the impact of technical measures on trade, in practice are very problematic to estimate empirically.

The survey of exporters of agricultural and food products provided a wide range of information on the impact of technical requirements on exports from the EU to the US. Key conclusions include:

v) Technical requirements, and in particular labelling requirements, are predominant factors influencing the ability of EU exporters to export agricultural and food products to the US.

vi) The impact of labelling requirements, food safety requirements and legal product quality requirements on the ability to export to the US differs on a product-by-product basis. Overall, however, these requirements have the greatest impact in the case of oil, fruit, vegetables and nuts, fish, dairy products and eggs and prepared foods.

vii) Comparing between different export markets, technical requirements have the greatest impact on the ability to export agricultural and food products to the US, Canada and Japan.

viii) A significant minority of exporters was required to have their production facilities approved before commencing exports to the US. The costs associated with this process were, in many cases, very significant, particularly for smaller companies.

ix) Around half of respondents had been required to reformulate their products before commencing exports to the US. The unit costs of such changes were, in many cases, significant.

x) Around a third of respondents considered their costs of production were greater than for an equivalent product manufactured domestically in the US. The mean excess costs of production were around 3 percent.

xi) Most respondents were subject to border inspection prior to importation to the US. However, relatively few had had consignments detained, although where this was the case costs were often significant.

Whilst this analysis almost raises as many questions as it answers, it does provide some insight into the impact of technical measures on EU agricultural and food exports to the US. Clearly, further work is required, although this study provides a good basis, indicating potential "problem" products and the range of technical measures to which they are subjected. Furthermore, it has highlighted the importance of the compliance process and the costs associated with different stages.



## 12. THE ECONOMICS OF NON-TARIFF BARRIERS

### Non-tariff barriers and market failures: Risk and informational aspects

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#### 12.1. Introduction

The objective of this part of the project (i.e., task 3) was to contribute to develop an analytical framework allowing to analyse the welfare effects of domestic food quality and safety regulations and to examine their ability to address market failures.

The starting point of the work developed within this part of the project is the following paradox. On the one hand, there is an agreement among trade practitioners that technical regulations are more and more often used for protectionist purposes, now that tariffs tend to come down because of international commitments on market access (OECD, 1999). Often, the protection of consumers or the environment is used as an argument for imposing stricter standards which, in fact, mainly aim to keep imports out. Numerous cases have been described where special interest groups have persuaded public authorities to back their case and erect health and safety barriers to imports, despite proof that risk levels were minimal (Hillman, 1978, 1997; Kramer, 1989; Roberts and Orden, 1997). Economists typically attribute the origin of such measures to rent-seeking or the capture of regulatory authorities by special interest groups (Stigler, 1975). In the case of environmental and safety standards, for example, regulators may be subject to political and economic pressures when deciding thresholds and framing regulations (Magat et al., 1986; Tullock, 1997; Powell, 1997). This legitimates the action of the World Trade Organisation (WTO), which addresses potential non-tariff trade barriers associated with food quality through the Sanitary and Phytosanitary (SPS) Agreement and the Technical Barriers to Trade (TBT) Agreement. With these agreements, barriers to imports must now be based on scientific grounds. The evidence of significant barriers to trade, caused by regulations whose motivation is primarily to protect vested interests, suggests that the action of the WTO should be deepened in the ongoing round of negotiations.

On the other hand, however, one cannot dismiss that consumers, especially in Europe, have genuine concerns about the safety, quality and ethical correctness of imports (i.e., environment, child labour, animal welfare, etc.). These concerns should be addressed unless taking the chance of a large scaled rejection of the whole trade liberalisation process. This legitimates regulations that might restrict trade provided that they protect and, to a certain extent, satisfy consumers. These regulations should also be designed so as to alleviate some market failures, namely those linked to imperfect information on

quality and that openness of market to new products tends to magnify. There is therefore a difficult challenge, that of defining rules for fair trade without jeopardising adherence to the trade liberalisation process. This requires sounder rules for defining what is a trade barrier and what is a legitimate regulation that addresses consumers concerns with minimal trade distortions.

In the sanitary and phytosanitary area, the WTO relies on a science-based approach. Basically, measures that tend to limit trade are legitimate but must be based on scientific evidence under both the TBT and SPS agreements. However, enforcement of international rules based purely on science has resulted in some controversies. Countries differ in their culture as well in their technical skills and their ability to enforce regulations. Domestic regulations often result from history, correspond to specific demands from consumers, or are designed to cope with a specific legal system which provides particular incentives for firms as far as product quality is concerned. This raises the question of the setting of international rules that enhance the process of trade liberalisation while ensuring an adequate level of protection for consumers.

More generally, this raises the question of setting efficient domestic regulations. Efficient would mean that the regulation manages to avoid market failures at a minimal welfare cost for the society. Clearly, there is a need for more investigation of the costs and benefits of regulations. This is true for the regulations that can act as trade obstacles, but also for the public intervention in a more general way since most of the measures that are discussed in the framework of the trade negotiations (e.g. sanitary and technical standards, denominations, labels, liability provisions, etc.), are not specific to the issue of international trade.

Hence, the development of an analytical framework appears as necessary for analysing the welfare effects of domestic food quality and safety regulations and be able to classify non-tariff barriers (NTBs) according to the degree to which they impede trade and/or actually address market inefficiencies.

The first idea that underlies the work undertaken within this part of the project is that the standard (neo-classical) normative framework used in public economics can be useful for addressing these concerns. Economics could be part of the "science-based, rules-based approach" that could be used for assessing the legitimacy of trade restrictions. Economics could also contribute to clarify international rules if disputes were solved using an economically based definition of what is a non-tariff barrier and what is a genuine correction of market failure. The need for an increased role of cost-benefit analysis in designing sanitary and phytosanitary legislation has also been emphasised, in particular by the Nobel prize winner Kenneth Arrow together with a group of economists in a manifesto published in the review "Science" (Arrow et al. 1996). The work presented may be considered as a first stage contribution in showing that economics could help quantify consumers concerns (through the use of

economic valuation of their preferences) and that the whole process of economic assessment could be a useful negotiation tool (Bureau and Marette 1999).

The second idea underlying the work undertaken within this part of the project is that the beneficial effects of trade liberalisation may be attenuated by spontaneous market inefficiencies. In such cases, government intervention can be modified in order to avoid negative effects and to maximize the gains from trade. There are at least possible causes of market failures that have been identified in the literature: imperfect competition, imperfect knowledge and the presence of risk. Public regulations should focus on alleviating market failures in the three cases. A logical consequence is that when it can be shown that a domestic regulation successfully addresses one of these three issues, even though it might result in restricting trade flows, the international community should acknowledge that there is a form of legitimacy which should be reflected in trade agreements.

Hence, section 2 of this chapter proposes several analytical frameworks aimed at illustrating how trade liberalisation may result in spontaneous or increased market inefficiencies. There are numerous possible cases where trade liberalisation may induce market failures. Two of them, that are particularly relevant in the context of food quality and safety standards, were retained: the presence of sanitary and phytosanitary risk and imperfect information on the quality of products.

The first developed model investigates the welfare impact of trade liberalisation between two countries experiencing different levels of sanitary risk and production cost, the consumers being unable to detect the origin of the product sold on the market. The second developed model relies on a similar framework but put special emphasis on the impact of trade liberalisation on the behaviour of sellers in terms of testing and signalling the quality of their product. In this case, both countries exhibit equal levels of sanitary risk and production cost, but differ in their ability to control product's safety. The third model explores the economic mechanisms affecting product safety when consumers face different information structures. Three cases are considered: the search good situation; the experience good situation (as defined by Nelson, 1970); the credence good situation (Darby and Karny, 1973). The fourth developed model is specifically designed for addressing the EU-US hormone-treated beef dispute. It corresponds to a particular case of the previous third model and is used for investigating the welfare effects of opening the domestic market (i.e., the EU market) where hormone-free beef is perceived as of higher quality to foreign products (i.e., US hormone-treated beef) that are perceived as lower quality goods.

Section 3 examines some issues related to labelling policies. Indeed, there are several ways to implement a label and this second stage of the analysis aims to further examine the effectiveness of various labelling strategies. More specifically, three main questions are addressed: when should a regulator promote public labelling and when should labelling be a mandatory or a voluntary programme? How should public labelling be financed? Under which conditions a label "does contain"

is more effective than a label "does not contain"? Lessons are drawn from developed analytical frameworks proposed in section 1.

Section 4 of this chapter proposes an assessment of the US sanitary and phytosanitary legislation, from the point of view of the WTO rules. A special emphasis is paid to the so-called Delaney clause.

Finally, section 5 concludes and draws some policy recommendations.

## **12.2. Trade liberalisation and market failures<sup>147</sup>**

### ***12.2.1. Trade liberalisation and imperfect competition***

The linkages between competition and product quality are complex. There is evidence that there might exist trade-offs between quality supply and competition. When this happens, by increasing competition, trade liberalisation may sometimes have a negative influence on the quality on offer. Greater competition may result in certain quality segments not being supplied at all, or in an overall decline in quality on the market (Gal-Or, 1989a). When firms have fixed costs, it has also been shown that greater competition can cause producers to set quality levels further removed from the socially optimum level in order to limit a fall in profits (Reitzes, 1992). *Ceteris paribus*, by increasing competition in an industry, freer trade could encourage quality-cutting or fictitious differentiation, especially if consumers track prices more readily than quality (Beales et al., 1981), or when there is a negative correlation between the quantity of output and quality (e.g., in sectors where quality depends on restricting yields).

The mechanism by which trade liberalisation (and more generally increased competition) may affect producer's choice and lower their incentive to enhance safety is illustrated in Box 12.1. Further details on the theoretical framework and obtained results are provided in Gozlan and Marette (2000). Relying on Industrial Economics, the used framework involves extremely simplified assumptions (the negative effect resulting from the possible decrease in effort is lower when one considers a bilateral opening of borders for example). In reality, markets are more competitive. However, the mechanism illustrated could occur in real life, since it is only an international extension of quality cutting competition.<sup>148</sup>

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<sup>147</sup> In most of the papers under this section of the project, the emphasis was put on simplified mathematical framework that aim at illustrating economic mechanisms rather than providing a faithful representation of the reality. Indeed, the analytical developments becomes rapidly mathematically intractable when models become sophisticated. The methodology adopted was to base the analysis on stylized economic mechanisms.

<sup>148</sup> For example, in many countries, domestic competition policy acknowledges that increased competition can result in lower quality. The regulator often permits barriers to entry, such as geographical barriers (e.g., areas of exclusive dealership in order to make sure that adequate maintenance services will be provided), or vertical contracts between processors and dealers. The purpose is to limit competition when it is acknowledged that this results in an increase of quality, and that this results in an improvement in collective welfare.

### Box 12.1. A Possible Case where Trade Results in Lower Quality Supplied

The purpose of the following stylised model, which draws from Gozlan and Marette (2000), is to show a possible mechanism where trade liberalisation lowers incentives for ensuring product quality.

For the sake of simplicity, assume that trade liberalisation results in a shift from a monopoly to an oligopoly. In a given country, consider a producer deciding upon a level of quality effort  $\lambda \in [0;1]$ . Although the demonstration is more general, we focus here on a safety effort. Without loss of generality, this effort can be identified as the probability of getting safe products. Only safe products are on demand. The cost of the effort is  $f\lambda^2/2$ , which is independent of the quantity produced. By assumption, the producer decides upon  $\lambda$  in a first step, on the basis of an expected price over the present and future periods (subgame perfect equilibrium). Consumers and suppliers are aware of the quality of the products on offer. Demand for high quality (safe) products can be represented as  $x = 1 - p/q_h$  (see Mussa and Rosen, 1978).

This follows the assumption of a continuum of consumers with different preferences  $\theta$  for quality, represented by a uniform unit distribution of a parameter  $\theta \in [0,1]$ . The net utility of each consumer willing to buy a unit of the high quality  $q_h$  for a price  $p$  is  $U = \theta q_h - p$ . The parameter  $\theta_0 = p/q_h$  characterises the consumer who is indifferent between acquiring the good or not, so that demand of high quality goods is  $x = 1 - \theta_0$ . The profit of the monopolistic supplier is  $\Pi = \lambda p(1 - p/q_h) - f\lambda^2/2$ .

By backward induction, profit maximisation leads to an equilibrium price  $p^* = q_h/2$  and to a quality choice  $\lambda^* = \text{Min}[1; q_h/(4f)]$ . When the unit cost of quality effort  $f$  is low, the effort is maximal, i.e.,  $\lambda^* = 1$ . This leads, by assumption, to production of safe products only. Overall welfare, the sum of consumers' surplus and producer's profit is  $W_A = \Pi_A + CS_A = 3q_h/8 - f/2$ . If  $f > q_h/4$ , the effort is  $\lambda^* = q_h/(4f) < 1$ , resulting in the possible production of tainted products. The effort decreases when  $f$  increases, and welfare is  $W_B = q_h^2/16f$ .

Now, assume that the country opens its domestic market to imports. The foreign supplier (denoted F) is similar to the domestic one (denoted D). Assume that they compete in price, provided that they both produce safe products. This occurs with a probability  $\lambda_D \lambda_F$ . Price cutting competition leads to a zero profit. Consumers' surplus is  $sc_c = \int_{\theta_0}^1 \theta q_h d\theta = q_h/2$  with  $\theta_0 = 0$  in that particular case where the market is covered. With a probability  $\lambda_D(1 - \lambda_F)$  the domestic firm is the only one to offer safe products and the foreign one faces no demand. The gross profit of the domestic producer is  $q_h/4$  and consumers' surplus is  $sc_c' = \int_{1/2}^1 (\theta q_h - p^*) d\theta = q_h/8$ . In the first step, the expected profit of the domestic supplier is therefore  $\Pi_D = \lambda_D(1 - \lambda_F)q_h/4 - f\lambda_D^2/2$ .

Turning to the choice of the quality effort, maximisation of the expected profit leads to a quality effort  $\lambda_D^{**} = \lambda_F^{**} = q_h/4f + q_h < 1$  as soon as  $f > 0$ . That is, the effort in quality is lower under free trade than under autarky, since  $\lambda_D^{**} < \lambda^*$ . The reduction in profit leads the domestic supplier to cut the quality effort. The resulting domestic welfare is  $W_C = q_h^2(q_h + 3f)/2(q_h + 4f)^2$ .

Denote  $f_1$  as the unit cost of quality effort so that  $W_A = W_C$ . The welfare under autarky is larger than under free trade for the domestic country when  $f \in [f_1; (q_h/2\sqrt{2})]$ .

The negative effect on welfare caused by the decrease in effort dominates the positive effect caused by increased competition (i.e., the reduction in deadweight losses). As a result, freer trade results in both a decrease in product safety and in domestic welfare. Conversely, the welfare of the domestic country under autarky is lower than under free trade when  $f$  is close to zero or when  $f$  becomes very large (i.e.,  $f < f_1$  and  $f > q_h/(2\sqrt{2})$ ), meaning that the effect of the fall in safety effort is offset by the reduction of deadweight losses. When  $f$  is close to zero the effort of both firms is close to the effort of a firm under autarky (i.e.  $\lambda^* = 1$ ).

### *12.2.2. Trade liberalisation and risk*

The existence of risk is also a source of economic inefficiency. By increasing trade flows, trade liberalisation also multiplies the probability of spreading disease and unwanted species, for example. The cost of spread of pests and pathogens can be high. The blocking of sewers in North American cities by exotic molluscs brought in on the hulls of cargo ships is one example of this phenomenon. Various outbreaks of food poisoning in the EU and the US caused by imported foods provide another example. This imposes costs on society, such as lower yields in the case of an epizootic or the spread of a plant pest, or healthcare costs. Trade liberalisation therefore modifies the "public good" aspects of food safety. For example, a country's reputation as a producer of safe food may suffer when there is an outbreak of a food-borne disease, affecting all exporters through the misdeed of only one producer. Trade liberalisation, which exposes consumers to less familiar products, may increase the number of cases where consumers have an inappropriate evaluation of the risk level, raising some very difficult questions for economists.

It is not easy to assess the extent to which any increase in sanitary and phytosanitary risk is attributable to international trade rather than other factors such as tourism, and estimating the social costs of these extra risks is difficult. However, the increased risk may limit the welfare gains from international trade and should, in any rigorous approach, be taken into consideration when assessing the gains resulting from trade liberalisation.

The theoretical framework developed here relies on both Industrial Organisation and Welfare Economics and involves simple specifications of a random contamination by pathogens. It is used to investigate the effect of opening the domestic market to a product of uncertain quality, i.e., which could be tainted by pathogens. The model and obtained results are reported in details in Bureau, Marette and Gozlan (2001). As this theoretical framework assumes that foreign producers cannot detect contamination of their products, the illustrated case is relevant in Nord-South trade and corresponds to observed consumers concerns against import from third world countries that would fall under the special treatment (Article 10 of the SPS agreement).

In the presence of risk, food safety inspection is a major issue. Questions arise on whether safety inspection and/or certification program be mandatory or a voluntary program would be more cost effective. Drawing on recent literature on Industrial Organization, a framework was proposed where public, third party certification provides food-safety information to imperfectly informed buyers (Crespi and Marette, 2000). The structure of an efficient public regulation was investigated. Using a simple single-period model that takes into account asymmetric information and the link between the structure of certification costs and the shape of fees, the authors also studied the costs and the benefits of food certification, and of the ways it should be funded in order to provide the right incentives for an efficient regulation.

### *12.2.3. The importance of informational aspects*

Risk of contamination is a particular form of imperfect information. However, this is not the only one. Imperfect information on the quality of products is also a major issue. Broadly speaking, if consumers are not fully informed about product characteristics they may consume a dangerous product, or acquire a quality they do not wish to consume, or pay a price that does not reflect the real quality of the good in question. In all these cases, the level of welfare in society may be lower than it would have been if information had been perfect. The workings of the market may cause vendors to offer an inadequate level of quality or safety when information is imperfect. The problem is likely to become more important while products come from further and more various origins. Because they are imported from countries that differ in institutional structure and regulatory framework, and therefore in their perceived ability to protect consumers from unsafe products and deceptive practices, the process of trade liberalisation raises consumer concerns about the safety of food products.

Since domestic consumers may value differently the quality attributes of domestic and foreign products, trade liberalisation, which results in the coexistence of both imported and domestic products on the same market, may affect consumers' beliefs on the average quality of products. It is well known since the work of Akerlof (1970) that market inefficiencies may stem from imperfect information and that consumers' expectations about product quality play a key role in the determination of aggregate welfare.

Consumer goods may be divided into search, experience and credence goods. A good is a search good when the consumer is capable of assessing its quality before buying it, an experience good when the consumer discovers the quality only after consuming it, and a credence good when the consumer never discovers the quality of the good (or does so only in the very long term). Search goods are goods for which perfect information can be acquired, albeit at a cost. The organoleptic components of quality (taste) generally fall into the "experience" category. But many agrofood goods fall into the "credence" category (Caswell and Mojduska, 1996). This is the case, for example, when the "safety" component of quality or the nutritional composition of a product are at issue. It is also the case with the ethical, cultural or environmental components of quality. The economic mechanisms at work in these three categories are different. With experience goods, for example, the incentives for quality fraud are limited by consumer sanctions on the occasion of repeat purchases. With credence goods, there is no spontaneous mechanism for market regulation and it is more difficult to indicate quality in a credible way. The market failures highlighted by Akerlof may extend into the long term (see Box 12.2).

### Box 12.2. Imperfect information and market inefficiency

Imperfect information about product quality can cause market dysfunctions affecting the price and quality of traded goods. Two major types of problems are generally identified. In the case of adverse selection, vendors do not decide the quality of their products. In the case of moral hazard, vendors do decide the quality of their products. With regard to food safety, for example, long-term risks and risks over which producers have no control fall into the adverse selection category, while risks over which they do have control fall into the moral hazard category.

When consumers are not able to distinguish the specific quality of different products, they are not willing to pay as high a price as they would if they were sure that the product was of high quality. Akerlof (1970) has shown that imperfect consumer information about product quality could even result in total closedown of the market (absence of trade) if, because of a lack of information, buyers' willingness to pay was insufficient to cover production costs. If buyers' willingness to pay is less than the cost of producing high quality goods, only low quality goods (less costly to produce) are traded and high quality is frozen out of the market (Akerlof quoted second-hand cars as a famous example of poor quality chasing away high quality).

In order to alleviate these dysfunctions, vendors may signal the quality of their products. For an experience good, this signal may be communicated through the price. In the case of moral hazard, Shapiro (1983) has shown that a higher price than the perfect information price could encourage producers to offer high quality on a lasting basis. This price supplement constitutes the information rent, which enables quality to be maintained over time and creates an incentive not to cheat on quality.<sup>149</sup> This can be a way of segmenting the market and informing consumers. However, there is a cost to society in comparison with a situation of perfect information, since consumers have to pay the higher price needed to signal quality. This mechanism does not work with credence goods. As consumers never detect the quality of the product, repeat purchases do not bring them any additional information and will not change their behaviour, thus not providing any incentive to producers to offer high quality.

The price mechanism described above is not the only way in which quality can be signaled. Firms can spend heavily on advertising, for example, and consumers will anticipate that such expenditure can only be covered by an information rent, indicating that the product is of high quality (if it is an experience good). Warranties or substantial compensation in the event of problems are other types of signal (Gal-Or, 1989b; Lutz, 1989). Firms can also secure a reputation via a trademark or a quality signal such as a label. Governments can enhance the credibility of quality signals by certifying them. Conversely, consumers may use intermediaries such as brokers or dealers who, better informed, can give them credible information on the quality of the offered goods. In all these cases, however, imperfect information has a welfare cost to society.

When consumers know that they do not have complete information, markets are affected in a way that reduce transactions. When information is imperfect, trade liberalisation can encourage phenomena such as the elimination of high quality products or price distortions, especially where credence goods are concerned. There is a substantial body of research to show that information effects may limit the welfare gains made possible by trade liberalisation as a result of lower prices and greater product diversity (Falvey, 1989; Grossman and Shapiro, 1988).

Economic literature suggests that regulation on product safety cannot be considered independently of the competition structure (Daughety and Reinganum, 1997). Many normative results on safety regulation depend on the combined effect of information and competition (Donnenfeld et al, 1985).

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<sup>149</sup> A high quality producer has an economic interest in preserving his reputation. If he sold a poor quality product with a high quality price ticket, buyers detecting the quality after consuming the product would not buy from the same producer again. The cost of establishing a reputation, which can be amortised only by the

#### *12.2.4. An economic assessment/definition of non-tariff barriers: The case of the EU-US hormone-treated beef dispute*

The case of the hormone-treated beef between the EU and the US provided the opportunity to assess the WTO rules regarding non-tariff barriers in the light of the three mechanisms previously described by which trade liberalisation may generate or increase market failures resulting from the combined effects of risk and imperfect information.

The TBT and SPS agreements limit the freedom of WTO member countries to define technical regulations. Together with the Dispute settlement body of the WTO, they make it possible to settle disputes on technical trade barriers. Thanks to the reliance on the *Codex Alimentarius*, such agreements contribute to making legislation consistent throughout countries. Nevertheless, full harmonisation of standards in all WTO countries is difficult. Moreover, it is not necessarily desirable either. The cost of providing a given quality differs a lot among countries, making a uniform standard economically inefficient. In addition, consumers of different countries do not have similar expectations about food quality and food safety regulations. Fundamental differences in the legal system for protecting consumers from health hazards provide some justification for diverging conceptions on the role of government in setting standards. Consumers' perceptions concerning the quality of a product may differ due to the specific eating habits of such or such country. For example, surveys show that in some European countries, consumers are more likely to pay a premium for products obtained without biotechnology than US consumers. This includes genetic engineering, as well as supplementing animals with hormones. In the case of beef, the use of hormones has given rise to a major dispute between the EU and the US. With trade liberalisation, information on the (subjective) quality of the products available might become more imperfect. This might bring about welfare losses, canceling some of the benefits of trade liberalisation.

Focusing on credence goods Bureau, Marette and Schiavina (1998) showed that the effects of trade liberalisation under imperfect consumer information were ambiguous. The coexistence of imports and local production can affect the perception of the quality available on the market. Trade liberalisation may therefore increase the imperfect information of consumers about quality. This may bring about market inefficiencies linked to adverse selection, such as a decrease in demand, the potential exclusion of a higher quality from the market, and the risk associated with the existence of multiple equilibria. The possible welfare losses caused by more imperfect information must be measured against the welfare gains resulting from increased competition, from international specialisation according to comparative advantage, and from an increase in product diversity.

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information rent, acts as an incentive and prevents low quality producers from signalling their products as high quality products.

In the hormone-treated beef case, they showed that it is theoretically possible that a WTO panel ruling against a national standard of a particular country affects consumers' behaviour in a way that offsets some of the benefits of trade liberalisation. Quantitative estimation of the different parameters involved would be necessary for a conclusive opinion in this particular case. Presently, the only figures available are very questionable, and a precise quantification of the welfare losses for EU consumers and producers would require, for example, experimental economics or contingent valuation techniques. If such cost-benefit analysis techniques showed that lifting the ban on imports of hormone-treated beef would likely result in a EU welfare loss above the corresponding surplus of US producers, aggregate world welfare would decrease. In that case the economic rationale for trade liberalisation on the basis of *Codex Alimentarius* standards would be questionable.

When trade liberalisation calls into question national regulations whose effect is also to reduce market inefficiencies, the welfare effects may be analytically ambiguous (Thilmany and Barrett, 1997; Bureau Marette and Schiavina, 1998). If a WTO panel, for example, results in an obligation to import products that do not satisfy consumers' ethical, environmental or cultural concerns, anti-selection mechanisms could cause substantial welfare losses. In practice, this could involve consumer boycotts or rejections, which would affect demand for all the goods concerned, both imported and domestic. Estimating overall costs and benefits would involve quantifying the different variations in welfare, raising awkward technical problems. Nonetheless, it is possible for welfare losses to be greater than welfare gains at a global level. It would be paradoxical if trade liberalisation, introduced by an international organisation in the framework of the settlement of disputes, were to result in more trade but less welfare.

#### ***12.2.5. An emphasis on welfare analysis***

As already mentioned in the introduction, the work undertaken within this part of the project puts emphasis on welfare analysis, and consequently on the use of cost benefit analysis in order to assess the legitimacy of public regulations that could act as trade barriers.

The point of view of the researchers involved in this section of the project is that, when cultures differ, economic analysis might help finding a common playing field. This issue has progressively been accepted in the area of environmental disputes, and it is progressing, albeit slowly, in the phytosanitary area, and, to a lesser extent, in the sanitary area. In this part of the project, a particular attention was paid to the possibility of a broader use of economic assessment in food quality regulations as well as in disputes settlement on non-tariff barriers.

Cost-benefit analysis is already used to enable public authorities to take decisions concerning national regulations. It is already an important stage in the framing of regulations in the United States. Arrow et al. (1996), recommend that the method should be used systematically, since they observed

considerable differences between the cost of public health measures and their real impact on health (they give estimates where, within the same agency, the cost per life saved varies between US\$200 000 and US\$10 000 000 depending on the program, which means that more lives could be saved at the same cost to society; see also Magat et al, 1986). Even though society does not accept all risks in the same way, and even though social choices cannot be reduced to the equalisation of a statistical cost between programs, cost-benefit analysis should take a more important place.

Box 12.3 describes a few possible techniques in order to introduce more economic assessment in the sanitary and phytosanitary regulations. There are clearly many technical difficulties. Measuring the benefits procured by regulations designed to guarantee certain subjective aspects of product quality is not easy, and the problem of the valuation of imagined risks is a difficult one (Pollak, 1995 and 1998). Estimates of cancer risk from pesticide residues contain a substantial degree of uncertainty as to the risk, making any economic estimate particularly difficult. Sometimes, it is not possible to calculate the probability of a risk that is too uncertain, making it difficult to carry out analysis with conventional tools. This is the case, for example, with the risk of genetically modified organisms propagating genes, or the risk of long-term epidemics such as Bovine Spongiform Encephalopathy or environmental risks. However, similar problems exist in traditional risk assessment procedures. With an economic approach, it is possible to use approaches based on the measurement of changes in the consumer utility function when consumers have access to a product with attributes to which they are attached (Kopp et al., 1997).

When human health is at stake, the topic is more sensitive since giving a value to illness avoided or even a human life saved is not always well accepted, especially in some EU countries. However, it is worth noticing that in the same countries, transportation and energy departments use such calculation on a daily basis when they decide priority investment in road safety or thresholds in dam buildings. Economic assessment would simply make choices more explicit, although concepts such as "the value of life" (actually, the value of life saved) can still be shocking for many people (Viscusi, 1993).

Cost-benefit analysis can be of particular interest as far as ethical or cultural values are concerned. If for example consumers place particular value on the fact that a good is produced without the use of biotechnology or irradiation techniques, estimating their willingness to pay means that the variation in consumer satisfaction resulting from a regulation prohibiting the technique in question can be quantified in money terms (Viscusi et al., 1995; Magat and Viscusi, 1993). One application could be the animal welfare issue, an awkward case where public opinion is being represented by vociferous consumer lobbies in Europe, and where scientists have proved being of little help. More economic assessment would make it possible to assess the real importance of this concern throughout the entire population.

### Box 12.3. Methods for Estimating the Benefits of Sanitary and Technical Regulations

Where food safety and the spread of plant and animal diseases are concerned, cost-benefit analysis involves quantifying the level of risk and estimating its economic impact. This approach is used, though very unevenly from one country to another, not only in order to assess the interest of a regulation but also to compare the advantages and disadvantages of several possible means of government intervention. In particular, it can be used to rationalise the strengthening of sanitary and phytosanitary controls in relation to the dissemination of information and the raising of consumer awareness, or to inform decisions about the introduction of regulatory standards (Kopp et al., 1997).

Although there are still some technical difficulties, there are few major obstacles to complementing classical risk analysis by cost-benefit analysis in the phytosanitary and animal health area. Things are more complex, however when cultural values are at stake, and when one deals with human health issues.

Several methods exist for estimating the cost of mortality and morbidity and evaluating in money terms the benefits of government action resulting in a reduction of sanitary risk. With the *human capital* method, a value is placed on the reduced risk of premature death based on an evaluation of discounted labour flow. For an individual of a given age, the value of the life prolonged (statistically) by a regulation corresponds to the discounted sum of the mathematical expectation of the person's revenues (Freeman, 1993). Some extensions of this method have been proposed, in particular by integrating non-merchant aspects and the value of the individual's descendants (Viscusi, 1993). With the *cost of illness* method, a value is placed on the reduced morbidity resulting from sanitary or regulatory methods, based on an estimate of medical costs and productivity losses due to illness (Buzby et al., 1996; Crutchfield et al, 1997). Opportunity costs from investing in activities that reduce the risk are included in the value of reduced illness (Landefeld and Seskin, 1982). As with the human capital method, statistical methods have to be used to estimate the risk, especially dose-effect relationships.

Methods based on estimates of willingness to pay, although more difficult to apply, are wider-reaching, since they make it possible to include quality-related aspects that cannot be translated into identifiable short-term illness. The *preventive expenditure* method seeks to measure agents' willingness to pay by observing the efforts made to avoid illness. With this method, a money evaluation of the disutility of being ill is added to the estimated cost of illness, together with an estimate of the preventive expenditure that an individual is willing to commit according to a given pathogen level (Harrington and Portney, 1987). *Contingent valuation* methods involve asking individuals directly about their willingness to pay in order to reduce the risk of an illness, or more generally to obtain higher quality in a good. By directly revealing willingness to pay, this method theoretically makes it possible to gain a money estimate of all the benefits arising from a given measure. However, answers have to be corrected for statistical bias due to respondents' incentives to over- or underestimate their willingness to pay (which depends in particular on whether they anticipate having to pay the disclosed sum or not). As these methods are widely applied to environmental issues, efforts have been made recently to harmonize survey methodologies (see, in the United States, NOAA panel, *Federal Register* 58,10). Another method being used increasingly widely at present is the *experimental economics* method, which involves getting a group of individuals in a situation where their real behaviour is simulated to reveal their willingness to pay for particular qualities. Such methods are relatively onerous to put in place, but they make it possible to obtain a precise measurement of the value that a sample of individuals places on different sanitary thresholds, according to information received, for example (Hayes et al., 1995).

The methods described above are used to evaluate the benefits of drawing up a regulation to protect consumers' health or to ensure that they acquire the quality they desire. Methods for evaluating the cost of regulations are generally based on estimates of the welfare loss of the agents concerned when they have to comply with a regulation. This includes for example the cost to firms of acquiring suitable equipment and many other direct and indirect costs. Kopp et al. (1997) provide illustrations of such estimates. One method involves valuing them as opportunities that had to be foregone. This includes the diversion of resources, the value of specific inputs that become useless, the excess cost of substitution technologies and the price differentials with replacement products borne by the consumer.

### 12.3. Defining efficient regulations which minimise welfare costs

Genuine consumer aversion for certain imported products, for sanitary or cultural reasons, is normally reflected in a willingness to pay in order to buy other goods which satisfy their concerns. Giving this willingness to pay greater importance in the settlement of disputes, by comparing it with the costs to other economic agents, would help take account of consumer preferences. This could also help to prevent detractors of a more open trading environment from linking trade liberalisation with an obligation to consume products that do not correspond to consumers' aspirations. More generally, the design of efficient regulation calls for more economic analysis of the costs and benefits. For example, regulations that would be based on consumers' information, rather than mandatory practices, could be more cost effective in some cases. So could regulations that would specify a target in terms, say of contamination, rather than an obligation of means, since they would avoid imposing a regulatory burden on the industry for which a particular sterilization method is more effective than the other.

The principle of equivalence (i.e., the acceptance of different processes and methods if they achieve the same result) is central in the SPS and TBT agreements. With the ongoing liberalisation of trade, cost effective domestic regulations will therefore be part of the competitiveness of the domestic industry. This requires a thorough assessment of the way regulations are designed in the European Union. The case of food safety is of particular importance, since there are often several ways to ensure that a product is safe (e.g., pasteurization, irradiation, quality control through Hazard Analysis at Critical Control Points techniques, etc.). There are also several ways to provide producers incentives to ensure the supply of an adequate level of food safety and quality (e.g., minimum quality standards, reputation-based mechanisms, liability, etc.). Not all of them have the same cost effectiveness.

Marette, Bureau and Gozlan (2000) explored the economic mechanisms related to the provision of product safety. They showed that the different types of regulation, i.e., minimum safety standards, labels and liability enforcement have different effects on the safety of the products supplied on the market and on the overall welfare, depending on the information structure. For example, a minimum safety standard can be an efficient policy instrument and lead to a higher collective welfare than the one on an unregulated market when consumers detect unsafe products prior to consumption. When they find out about production safety after consumption, the prospect of future sales provides incentives for firms to supply safe products. However, market mechanisms can be usefully complemented by a minimum safety standard or a liability policy when the spontaneous provision of safety is less than socially optimal because of the high cost of the safety effort.

The particular case where consumers do not detect the safety of the product even after consumption (or where they only do so after a very long period) is a challenge for regulators. Because of the absence of verification of their claims in the medium run, sellers have no incentive to implement

(costly) signals in order to inform consumers of the harmlessness of their products. They can therefore be imitated by suppliers of unsafe products. Market forces may lead to a less-than optimal provision of safety, and possibly in the absence of trade à la Akerlof (1970). In such cases, a minimum safety standard or a label is necessary for making trade possible. This label must however be backed by certification from a third party able to monitor the effort level. When effort safety is very costly, though, market closure may persist.

### ***12.3.1. Voluntary versus mandatory certification***

On the question of voluntary versus mandatory certification, Crespi and Marette (2000) find that if there is more than one seller of a safe product, voluntary certification financed by a per-unit fee is sufficient, because competition incites all such sellers to certify their products. If there is only one seller with safe products, mandatory certification is needed if the cost of certification is high. Moreover, in this monopoly case a fixed user fee is more efficient than a per-unit fee in improving welfare. They also considered the case where certification is performed by private organisations. If there is only a single private agency (e.g., if the government grants an exclusive license) then a monopoly allocation by this agent results in the imposition of a welfare distorting per-unit user fee. However, when private certifiers compete to provide certification services, welfare under private certification is the same as that under public certification.

### ***12.3.2. Is labeling a way to solve market inefficiencies resulting from trade liberalisation?***

When confronted to the idea that trade liberalisation might result in more risky, or simply less familiar product sold on the market, possibly leading to adverse selection, international organisations often suggest labeling. Indeed, this appears as an interesting solution. Beales et al (1981) have shown that segmenting the market, and allowing for each group of consumers to buy the products corresponding to their willingness to pay, is, in theory, a much better solution than mandatory uniform standards. As a result, labeling and consumer information policies are often portrayed by international organisations as preferable alternatives to regulation because they are cheaper for producers, leave the choice to consumers and are less likely to constitute trade barriers (OECD, 1997).

However, in practice, labeling does not solve all problems either. First, labeling is not always possible, or, when it is, it can be very expensive. The proposals for a strict labeling of Genetically Modified Organisms (GMOs) in Europe, require complete traceability, that is, that the whole chain be segmented, from the producer to the final processed product. According to the industry, this would generate very large costs (a Canadian study into segregating modified wheat products found this would require separate facilities at 15 different points from farm to market). In addition, pollen is known for spreading between controlled and uncontrolled areas (some pollen was found at several

kilometers in altitude), and the segmentation of the two markets can hardly be perfect. In some other cases, labeling is simply not the solution that consumers are willing to accept. For example, animal welfare activists have clearly stated that labeling was not an issue and that they wanted an interdiction of certain rearing practices.

Another reason why labeling is not the panacea described by some economists, is that the conflicts about the appropriate level of standards are sometimes simply displaced toward the issue of the appropriate label, which is equally complex. There are diverging opinions, for example, on the relevance of labels on clothing certifying low levels of pesticide use in the production of cotton, or on the specifications for labels certifying that wood products do not harm tropical rainforests. Mutual recognition of labeling for organically farmed products is difficult to achieve because countries apply the relevant criteria more or less strictly, or because some countries are considering granting such labels to genetically engineered or irradiated products. Basically, the need for international harmonisation/recognition of labels and of the underlying certification procedures raises difficulties that are comparable to the ones raised by the harmonisation/recognition of mandatory standards.

Finally, economic theory suggests that, if agents are rational, a label on credence goods should not be sustainable. The idea is that rational consumers know that they cannot verify that producers fill their commitments, while rational producers have no reason to do so. Labels on credence goods require a third party certification, and, in spite of that, are not always trusted by consumers. In particular, it is difficult to monitor the production process of imported credence goods, which is the sole means for acquiring information about their quality. Foreign firms are also less exposed to judicial sanctions (liability), which may encourage fraud when the consumer is unable to verify the quality of the good in question directly.

Crespi and Marette (2001) have provided more insight to the case of labeling. They examined the effects of GMO labeling. Using a simple, single-period, asymmetric-information model that takes into account the link between labeling and its cost, they showed that there the impact on welfare of labeling could vary a lot, depending for example on whether a mandated label reads "Does Contain GMOs" or "Does Not Contain GMOs". This result shows that a potential trade dispute between the European Union and the United States on the status of GMOs labeling could have complex implications. The outcome for the two parties would be very different, depending on the sort of label that is used.

Marette and Gozlan (2000) addressed the effect of trade liberalisation and consumers' information on the quality and safety of products. Because it increases competition, trade liberalisation may restrict firms' profit. Such a situation may involve a race to the bottom as far as quality supply is concerned, when consumers' information on quality is imperfect. This problem arises in particular in the case of credence goods. This can be a problem in the case of genetically modified products, for example. This

means that labels or appellations of origin may increase aggregate welfare and therefore should not be considered as non-tariff barriers even though they may sometimes have the effect of discriminating against imports.

#### **12.4. An assessment of the US system of food safety regulation and the possible outcome of WTO disputes**

The sanitary and phytosanitary legislation of the United States and the European Union differ in many aspects (see chapter 11). There have been some disagreements on the legitimacy of such or such regulation, that could result in obstacles to exports of the other country. Such a disagreement turned into a formal dispute in the case of the use of hormones in the production of beef, but there are also other disagreements on the use of hormones in dairy production, on hygiene rules in slaughterhouses (the use of chlorine in poultry in the US is criticised by the EU), on GMOs, etc.

Doussin and Macé (2000) described the major differences in the EU and US regulatory system that explains the disagreements between these two trade partners. They showed that the divergence was related to the recognition of the "other legitimate factors" than the sanitary issues in the *Codex Alimentarius*, which is illustrated, for example, by the difference of interpretation of the scope of the precautionary principle. This was part of the dispute on hormone-treated meat, until the Appellate body of the WTO clarified the scope of this principle, or more exactly of the Article 5.7 of the SPS agreement that refers to the precaution issue.

Doussin and Macé (2000 et 2001) also provided an extensive description of the US regulatory system. They show that there are multiple agencies in charge, which could create some confusion for would-be exporters. As a general feature, the whole US system relies on a "science-based approach", which explains some of the reluctance of the US administration to include some other aspects than the biological quality of food, that Europeans are attached to. However, there is a contradiction in the US approach, since one of the provisions of the US Food, Drug and Cosmetic Act, the "Delaney clause" acts as a precautionary clause, and is hardly science-based. Since 1958, this piece of the US legislation forbids the sale of food that contains cancer inducing substances, in particular additives, regardless of the level and proportion of such substances. This disposition presents some common points with the precautionary principle, since it relies on a "zero tolerance" concept, in front of the major uncertainty that resulted from the exposition to such substances in the fifties. This clause is largely inconsistent with both the "sound science" approach of the US legislation, but also with the provisions of the SPS agreements and Codex rules regarding the "zero risk option".

Bureau and Doussin (2000) examined the practical effects of the ruling of the WTO panels on sanitary and phytosanitary issues. Arbitration of recent SPS disputes clarified the right of a country to set a

particular level of protection, as well as the role of international standards. Building on the recent jurisprudence of the disputes settled under the WTO, they explained the practical scope of the SPS and TBT agreements. They presented the way possible disputes between the EU and the US could be handled by the WTO Dispute settlement body, and what would be the empirical consequences for trade. They focused on three examples: the Bovine somatotropin (Bst) issue, the controversy on mandatory pasteurization of cheese, and the definition and labeling of yogurts.

Their analysis of the possible outcome of a dispute under the WTO regarding Bst suggests that the European Union could have solid arguments for justifying the ban on Bst.<sup>150</sup> A large body of analysis has been carried out on potential dangers of using Bst, but the results are highly controversial (Morris, 1999). Critics of the hormone suggest that both Bst and its mediator, Insulin-like Growth Factor 1 (IGF-1), are found at higher concentrations in milk from treated cows. Canadian researchers concluded that long-term toxicity and oral absorption had not been fully studied and that possible hypersensitivity reaction "deserves further study" (Health Canada, 1999). Rejection of Bst by Canada and by several national EU veterinary committees was also based on reports of adverse effects for cows, including lameness, mastitis, and reduced lifespan. The US Food and Drug Administration and most other agencies interpret the data differently. For example, the Joint FAO/WHO Expert Committee on Food Additives concluded that Bst "does not represent a hazard to human health". The hormones Appellate body decision suggests that precautionary measures could be legitimate where there is scientific controversy, provided that some serious risk analysis had been performed.

The outcome of a potential challenge of restrictions to imports of raw milk cheese by the EU would be uncertain. The United States restrictions could be seen as lacking consistency, since a number of States permit the production and marketing of such products. On the basis of the ruling of the Appellate body in salmon, one might consider that there is a violation of the SPS provisions about consistency of the regulation. However, according to the SPS Agreement (Art 4.1.), the EU would have first to demonstrate that the European system of risk management makes it possible to reach the level of consumers' protection deemed appropriate by the United States. The US could challenge this demonstration on the basis of scientific arguments by referring to the large body of scientific research made in universities and agencies on this topic.

Since the beginning of the century, yogurts in most western European countries have contained live ferments. In the 1980s, several other countries have started to sell post-thermized (i.e., sterilized) yogurts, resulting in much lower logistic costs along the food chain since refrigeration is no longer

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<sup>150</sup> Note however that the disagreement between the EU and the US within the *Codex alimentarius* has never resulted in a formal dispute, one of the reason is that the EU, while banning use of Bst, does not ban imports of products obtained by using Bst in other countries.

necessary. In the EU the use of the term yogurt is restricted to those product that contained "a large amount" of well-defined lactic bacteria. The European Court of Justice ruled that free circulation across Member States of products denominated as yogurt could only be granted to those that conformed to this definition. Given the economic interests at stake, such decisions about the definition of products are of considerable importance. Codex standards are important also under the TBT Agreement, which deals with conditioning, packaging and composition. GATT panel decisions have established the general principle that international rules do not permit WTO members to restrict the imports of products on the basis of how they are produced. The TBT Agreement limits the scope of this principle by accounting for Processes and Production Methods (PPM), but the degree in which measures referring to PPM can be legitimate remains under debate. National measures based on PPM are more likely to be admitted if the production method clearly affects the quality of the product. That is, there is a need for scientific research that highlights the nutritional aspects of the products, if a country wants to protect a particular tradition or know-how.

## **12.5. Conclusions and policy recommendations**

### ***12.5.1. New criteria for defining trade barriers***

As traditional barriers to trade come down, regulatory reform has become a more important trade issue (OECD, 1998). The SPS and TBT Agreements have provided significant momentum towards the use of international standards. Increased notification requirements for both TBT and SPS regulations and the desire to avoid WTO dispute settlement procedures should make countries more aware of and careful about the international impacts of their regulations aimed at protecting human, animal or plant health. A number of disputes involving several OECD countries have already been brought before the WTO since the dispute settlement procedure was established in 1995. With the strengthening of international rules, globalisation of the food industry, increased trade in consumer food products and the growing use of biotechnology, trade conflicts over food regulatory issues and their reform are likely to become more common. The economic stakes are high and such disputes are likely to remain a priority in the future trade agenda.

There are many arguments for trade liberalisation, and most of them remain unchallenged by recent developments in economic theory relating to differentiated products. Country specialisation according to comparative advantage leads to lower real prices and hence, for a given level of expenditure, allows the possibility of consuming the same amount but a higher quality of products (vertical differentiation). In other cases, trade liberalisation reduces the cost of the consumer's preferred basket (horizontal differentiation). Countries can take advantage of growing economies of scale when markets are opened up, this in turn reduces production costs at constant quality. The increased competition resulting from trade liberalisation encourages firms to offer a better quality/price mix. In

addition, international trade increases product variety, and freedom to choose generally has a beneficial effect on consumer welfare, since welfare suffers when regulatory barriers prevent consumers from gaining access to higher quality foreign products. International trade also favours the rapid spread of technology, stepping up the pace of technological progress, which in turn favours an increase in product quality at constant prices.

However, the beneficial effects of trade liberalisation may be attenuated by spontaneous market inefficiencies. This falls in the general category of cases particularly well described by Stiglitz (1994) where incomplete markets (including incomplete markets for risk), non convexities and imperfect information limit the scope of the central welfare theorem, which are implicit in the standard legitimisation of trade liberalisation. In such cases, government intervention can be modified in order to avoid negative effects and to maximise the gains from trade.

### *12.5.2. Lessons for the WTO dispute settlement*

A conclusion of the work presented in this chapter is that the dispute settlement in the area of sanitary and technical barriers should rely on economic analysis to a much larger extent than it is presently the case. Presently, the SPS Agreement does not require any cost-benefit analysis when a country adopts a sanitary measure. Should a country be able to prove that there is a risk of dissemination of a pathogen, and even if the risk level were small, the economic consequence of dissemination negligible, and the economic costs of the ban considerable, the ban would be legitimate. On the other hand, the SPS framework does not allow trade restrictions when there is no evidence of risk, even if trade liberalisation should lead to very costly market failures, because of imperfect information, for example.

In international disputes, cost-benefit analysis could be a way to define the legitimacy of technical barriers and national regulations that affect trade. Baldwin's criterion states that a NTB should be defined as a measure that reduces the potential world income, rather than a measure that restricts trade flows (Baldwin, 1970). In spite of some shortcomings, such a criterion could be a basis for dispute settlement, as proposed by Mahé (1997).<sup>151</sup> The impact of regulatory measures on the aggregate welfare should be taken into account in disputes under the SPS and TBT agreements. The research developed in the case of hormone-treated beef shows that costs and benefits of regulations depend on

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<sup>151</sup> The Baldwin criterion relies on a Kaldor compensation test whose practical usefulness as well as ethical foundations are controversial. In international trade negotiations, the criterion that a situation B should be preferred to a situation A because, when one shifts from A to B, the gains for some agents in A are larger than the losses for other agents is not likely to lead to unanimous decisions, unless compensation is actually given to the losers.

costs of production, consumers' aversion to the product, and the cost of informing consumers. This suggests that the welfare effect of trade liberalisation may differ according to each particular issue. The overall welfare effect of consumers' aversion in the case of hormone-treated meat, may be very different from the one, say, in the case of genetically modified grains.

A more systematic economic analysis of the rationale for regulations and deregulations would improve the recording of consumers' expectations in the WTO dispute settlement procedure. Consumers' beliefs on what constitutes this quality may differ from scientific concepts. However, if consumers have genuine preferences for characteristics of the products that are not based on science, i.e., if these characteristics affect their utility, there is no particular reason for restricting the many dimensions of quality to a single attribute, i.e., respect of *Codex Alimentarius* standards on food safety. In international negotiations involving food quality, the measuring of willingness to pay may be a way to give a proper weight to cultural or ethical characteristics which consumers are genuinely attached to. Relying on welfare economics is not necessarily more subjective nor questionable than relying only on "sound science", which is often mandated or negotiated science (Salter, 1988; Powell, 1997). Since well designed cost-benefit analysis takes consumers' preferences into account, including it more often in the analysis may help improve the image of the word "globalisation" in public opinion, and may prevent consumers from associating trade liberalisation with the foisting on them of unwanted foods.

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