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To subsidize or not to subsidize private  
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Fabienne Femenia\*

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\*UMR 1302 SMART, INRA, Agrocampus Ouest, 4, allée Adolphe Bobierre, 35011  
Rennes, France, fabienne.femenia@rennes.inra.fr

### **Abstract**

We study here the effects on agricultural markets volatility of a public subsidy to private storage set up after a CAP reform. This kind of instrument is indeed often advocated in current international debates focusing on the management of agricultural price fluctuations. We use a dynamic Computable General Equilibrium model to simulate the welfare and market stabilizing impacts of such a subsidy. The model we use assumes that agents have imperfect expectations, which allows a representation of the endogenous dimension of agricultural market volatility. Our results corroborate the fact, often advocated, that removing the european price support scheme tends to increase the agricultural markets volatility in the European Union and to decrease this volatility in the rest of the world. Furthermore, we show that private stockholding behaviours allow a reduction of market volatility, both before and after the political reform. On the other hand, the set up of a public subsidy aimed at stimulating private stockholdings comes to scramble the market signals sent to agricultural producers and therefore has a destabilizing effect.

Keywords: CAP reform, storage subsidy, market volatility

## 1 Introduction

The stabilization of European agricultural markets, which was one of the initial objectives of the Common Agricultural Policy (CAP), is today questioned. Indeed, successive reforms have progressively replaced the price support scheme initially set up by the CAP, by a system of payments more and more decoupled from production and prices. While still supporting agricultural incomes, this evolution tends to reconnect European to international agricultural markets, and so to expose European agricultural producers to market fluctuations they did not face in the past. Regarding this increase of European farmers' exposure to market risks, more and more attention is being paid today to private risk managing instruments. Some of these instruments, including storage, already existed in the past but were not extensively used by agricultural producers, notably because of the existence of a public price support. Thought, private storage behaviours, which derive from inter temporal arbitrages, tend to reduce price volatility and can therefore stabilize markets (Makki et al., 1996).

One can presume that, with the removal of the public price support, private storage will be more and more used on European markets and will mitigate the increase of market volatility induced by this removal. There is however some limits to the use of private storage as a risk managing instrument. Anderson (1992) notably shows that the markets' stabilization induced by stockholding behaviours is very sensitive to storage costs: a small decrease of storage costs can generate a huge decrease of price volatility. This raises the question of the opportunity of a public intervention on storage. More and more attention is besides being paid to the opportunity of such an intervention at the world level (see the recent propositions of von Braun and Torero (2009), for instance). One way for governments to intervene on storage is to directly buy or sell stocks, so as to contain market prices, within a band determined by a support price and a release price for instance. This kind of mechanism was besides formerly used by the European Union (EU) to keep agricultural prices above an intervention level and stabilize markets. Nevertheless, public stockholdings have proven to be very costly (Jha and Srinivasan, 1999). Furthermore this mechanism generates a decrease of price volatility, which is a necessary condition for private storage to hold, and thus discourage private stockholdings (Glauber et al., 1989; Zant, 1997). In the United States (US), for instance, the removal, in 1996, of the public storage scheme in agricultural sectors led to an increase of the private storage activity and thus induced almost no changes in the volatility of agricultural prices (Lence and Hayes, 2002). Finally, buffer stock mechanisms can have an impact on production decisions, turn out to be distortive and do not

comply with the World Trade Organisation (WTO) rules. Another way for governments to intervene on private storage is to stimulate private storage by providing a financial support to stockholders.

In their study comparing different market stabilization programs, Glauber et al. (1989) conclude that subsidizing private storage is the most cost effective way to stabilize market prices because storage subsidies can easily adjust to stochastic phenomena. Choi and Meyers (1989) however question these results, arguing notably that they do not account for the (positive) impacts of storage subsidies on production decisions in their model. Furthermore, the issue of the impact of such subsidies on speculative behaviours should be considered. Indeed, it has often been mentioned that the behaviours of non rational speculators could destabilized markets (Ravallion, 1987, for instance). Femenia (2010), using a dynamic Computable General Equilibrium (CGE) framework shows that even if they are not fully rational speculative behaviours stabilize agricultural markets, and thus contradicts this assumption. One can however wonder about the new behaviours a storage subsidy could induce. Taking account of all agents' behaviours, as a can CGE model do, to study the effect of storage subsidies thus seem important. Furthermore, as shown by Jha and Srinivasan (1999) greater price stability achieved through a government intervention does not necessarily imply greater welfare for economic agents; indeed, in that case too much price stability eliminates private storage and generates very high government costs, which decreases social welfare. Here again CGE models thus seem the most appropriate to simulate global welfare effects. Yet, whereas CGE frameworks are widely used to study the effects of agricultural policies, none of the aforementioned works dealing with private storage subsidies has been conducted using a CGE model. One of the main reasons for that is probably that, as pointed out by Wright and Williams (1988), studying the effects of market stabilization mechanisms requires a dynamic framework and, in the case of storage subsidies, the modelling of stockholding behaviours. However few CGE models display such characteristics. Among them is the inter temporal dynamic CGE model developed by Femenia and Gohin (2009a) and Femenia (2010) which includes stockholding behaviours and can incorporate imperfect expectations.

Our main objective in this paper is to simulate the impacts on markets fluctuations following CAP reforms of a subsidization of storage costs aimed at stimulating private storage at the world level, and to study the welfare effects of this public intervention. To do so, we use the aforementioned dynamic CGE model. We also rely on the work of Femenia and Gohin (2009b) to adequately represent the CAP in the model. We simulate the effects of a radical reform: the complete removal of the CAP in arable crops sectors and

study the impacts on the volatility of agricultural markets of a storage cost subsidy set up in the Rest of the World (RoW) .

We find, as expected, that the CAP removal in arable crop sectors destabilizes European markets and tends to stabilize markets in the United States (US) and in the RoW. Our simulations also confirm the smoothing effect of private storage on market fluctuations. However, the subsidization of private storage, even if it boosts the world stock levels, has a destabilizing effect on agricultural markets. In fact, this subsidy, by lowering the occurrence of stock shortages, and their associated moderated price spikes, deprive economic agents, and farmers in particular, of market information. Once these subsidies are set up, agents are thus less prepared to stock shortages that still (but less frequently) arise, which eventually leads to very large price spikes, and so to larger market volatilities. These subsidies do thus not prove to be efficient in terms of market stabilization. Neither do they prove to have positive effects in terms of welfare. In fact, because the demand for private stocks increase following the subsidies set up, good quantities available for consumption decrease; this induces welfare losses at the world level.

In the next section we briefly recall the main features the dynamic CGE model. Then, we present the data used with a particular focus on the way the “standard” data have been modified to improve the modelling of the CAP instruments in arable crop sectors, we also present the policy scenarios that are simulated. The last section is devoted to the presentation of our main results. Finally we conclude.

## 2 The model

To be able to study the effects of different storage subsidies on market volatility, while accounting for both the linkages between agents’ inter temporal decisions and for the potential role of imperfect expectations, we use a dynamic CGE model developed by Femenia and Gohin (2009a) and Femenia (2010). This model is based on a version of the GTAP framework (Hertel, 1997) adapted to the study of agricultural markets. The main distinctive features of this dynamic model are as follows .

### 2.1 Dynamics

As usual in dynamic CGE model, the accumulation of capital stocks is used as link between periods: sectoral capital stocks accrue from one period to another in each region:  $K_{irt+1} = (1 - \delta_{ir}) K_{irt} + I_{irt}$ , with  $K$  the capital stock,  $I$  the new investment and  $\delta$  the depreciation rate of capital, the subsets

$i$ ,  $r$  and  $t$  denoting respectively the sector, the region and the time period concerned. In addition to this usual linkage between periods, Femenia and Gohin (2009a) give an inter temporal dynamic dimension to their model by introducing the inter temporal dimension of producers' investment and households' savings decisions:

To take his investment decision the producer seeks to maximize the present value of his firm (Devarajan and Go, 1998), which corresponds to the discounted value of all his expected future profits (capital income) minus his expected future investment costs:

$$\max \pi_{ir} = \sum_t \frac{1}{(1+r)^t} \left( wk_{irt} K_{irt} - PI_{irt} \left( 1 + \frac{\phi}{2} \frac{I_{irt}}{K_{irt}} \right) I_{irt} \right)$$

$$s.t. \quad K_{irt+1} - K_{irt} = -\delta_{ir} K_{irt} + I_{irt}$$

With  $r$  the interest rate,  $wk$  the capital income,  $PI$  the price of investment and  $\phi$  an adjustment parameter: the term  $\frac{\phi}{2} \frac{I_{irt}}{K_{irt}}$  represents the adjustment cost of capital (McKibbin and Wilcoxon, 1999). Solving this optimisation problem leads to a condition determining the optimal investment in each sector and each region:

$$\begin{aligned} wk_{irt+1} + (1 - \delta_{ir}) PI_{irt+1} \left( \phi \frac{I_{irt+1}}{K_{irt+1}} + 1 \right) = \\ (1+r) PI_{irt} \left( \phi \frac{I_{irt}}{K_{irt}} + 1 \right) - \frac{\phi}{2} PI_{irt+1} \left( \frac{I_{irt+1}}{K_{irt+1}} \right)^2 \end{aligned} \quad (1)$$

Then because, as we will detail later, producers have limited knowledge about output price, capital returns and interest rate in the far future, they are assumed to consider that the economy will reach a steady state at some future period. This “producer steady state” may never arise, because they periodically revise their plans, but this formulation allows to determine the optimal firms' investment plan at each period, and so their current investment.

Households also base their saving decisions on inter temporal arbitrages. Indeed they spend a part of the income they earn at one period to consume goods, which brings them some utility, and save the remaining part. The part of the income saved at one period will be used later to consume and thus represents a future utility. So, the representative household in each region seeks to maximize the value of its inter temporal utility, subject to an inter temporal budget constraint:

$$\max U_r = \sum_t \frac{1}{(1+\rho)^t} U_{rt}(Q_{rt})$$

$$s.t. \quad \sum_t \frac{1}{(1+r)^t} E_{rt} = \sum_t \frac{1}{(1+r)^t} (P_{rt}Q_{rt} + S_{rt})$$

With  $\rho$  a time preference parameter (households have a preference for immediate utility),  $Q$  the quantity consumed,  $P$  the composite consumer price,  $E$  the total income (including interest earned from foreign assets, factor returns, distributed profits and tax receipts) and savings. The first order condition of this program allows to determine the evolution of savings:

$$E_{rt} - S_{rt} = \left( \frac{1+\rho}{1+r} \right) (E_{rt+1} - S_{rt+1}) \quad (2)$$

As producers, households have limited knowledge about prices and incomes in the far future; they are thus also assumed to consider that the economy will reach a steady state at some future period. Once again, the steady state expected by households may never be reached but this condition, combined with Equation 2 allows to derive savings plan of households and thus current savings at each period.

These different characteristics of agents' inter temporal decisions, combined with a foreign debt accumulation period by period, are the main features of our model allowing the simulation of the dynamic evolution of markets.

## 2.2 Sources of market volatility

Two sources of price volatility on agricultural markets are identified in the economic literature (Butault and Le Mouél, 2004). On the one hand, many economists have argued that fluctuations on agricultural markets were essentially due to demand and supply shocks (Moschini and Hennessy, 2001): the time lag between production decisions of farmers and harvests induces a short-term rigidity of the agricultural supply, which can hardly adjust to market price changes. Furthermore most agricultural products are staples and demand for these goods is quite inelastic. Because of these two characteristics agricultural markets are very sensitive to market shocks: a supply decrease due to a, exogenous shock will result in a large price increase. Yet agricultural production is exposed to several epidemic and climatic risks and these exogenous shocks occur quite frequently, thus generating price fluctuations. On the other hand, the inter temporal dimension of decision processes implies that agents have to form expectations about the future path of economy at the time they take their decisions. Many studies dealing with uncertainty assume rational expectations (Williams and Wright (1991) for instance). However, processing and collecting information can be costly and

it can in fact be more rational for economic agents to form imperfect expectations (Just and Raussier, 2002) and thus make expectation errors. As formalized by Ezekiel (1938) in his Cobweb theorem, these expectation errors can spread over time and induce endogenous fluctuations of market prices. Fluctuations on agricultural markets can therefore be first induced by exogenous stochastic shocks and then endogenously amplified and spread over time by the imperfect nature of economic agents' expectations. These two aspects are introduced in the model as follows.

Firstly, the agricultural technology is represented in the model by a nested CES production function. The first nest combines production factors to create value added; the second one combines the aggregate factors with intermediate consumptions to produce output:

$$\begin{cases} VA_{irt} = \gamma_{ir} (a_{ir} K_{irt}^{\rho_{ir}} + b_{ir} L_{irt}^{\rho_{ir}} + c_{ir} T_{irt}^{\rho_{ir}})^{\frac{1}{\rho_{ir}}} \\ Y_{irt} = \Phi_{ir} (\beta_{ir} VA_{irt}^{\theta_{ir}} + (1 - \beta_{ir}) IC_{irt}^{\theta_{ir}})^{\frac{1}{\theta_{ir}}} \end{cases} \quad (3)$$

With  $VA$  the value added,  $L$  the labour factor,  $T$  the land factor,  $Y$  the quantity produced and  $IC$  the aggregate intermediate consumption.  $a$ ,  $b$ ,  $c$  and  $\beta$  are share parameters,  $\rho$  and  $\theta$  determine respectively the degree of substitutability between capital, labour and land and between value added and intermediate consumption, finally  $\gamma$  and  $\Phi$  are productivity parameters. Exogenous supply shocks are introduced through the productivity parameter  $\Phi$ : Random disturbances  $\epsilon$  are thus introduced such that  $\Phi shock_{ir} = \Phi_{ir} (1 + \epsilon)$ , with  $\Phi shock_{ir}$  the "shocked" productivity parameter. We assume that  $\epsilon \sim N(0, \sigma_\epsilon)$  which implies that  $\Phi shock_{ir}$  fluctuates around  $\Phi_{ir}$  with a variance equal to  $\sigma_{\Phi shock_{ir}}^2 = \Phi_{ir}^2 \sigma_\epsilon^2$ , that is to say that the  $\Phi_{ir}$  values calibrated from the initial data correspond to average expected values.

Secondly, assuming that farmers have the right information concerning their own productivity (that they know the distribution of the exogenous shocks affecting their production) seems quite obvious. On the other hand, their expectations about market prices are assumed to be imperfect, which introduces an endogenous source of volatility in the model.

For that purpose we follow Femenia and Gohin (2009a) and rely on Nerlove's work (Nerlove, 1958) who proposed a formalisation of adaptive expectations based on past information. These expectations are such that agents take their past expectation errors into account to form their new expectations:

$$\hat{P}_{t+1} = \hat{P}_t + \alpha [P_t - \hat{P}_t] = \alpha P_t + (1 - \alpha) \hat{P}_t \quad (4)$$

$\hat{P}$  denotes expected prices and  $P$  observed market prices,  $\alpha$  can be seen as a measure of the adjustment speed of expectations.

### 2.3 Modelling of storage

Stockholding behaviours are introduced in the model as in Femenia (2010). Namely, one representative stockholder in each region holds stocks and can sell a part of these stocks or buy other stocks at current market price at each period.

The stockholder seeks to maximize his intertemporal profit which corresponds to the discounted sum of his sales minus his purchases and the storage costs. His program can thus be expressed as:

$$\max \sum_t \frac{1}{(1+r)^t} \sum_i \left( -\hat{P}_{irt} \Delta_{irt} - k_{rt} ST_{irt} \right) \\ s.t. \quad ST_{irt} = ST_{irt-1} + \Delta_{irt}$$

With  $ST_{irt}$  the quantity of good  $i$  stored in region  $r$  at period  $t$ ,  $k_{rt}$  the endogenous unitary storage cost in the region, and  $\Delta_{irt}$  the variation of stock quantities ( $\Delta_{irt} > 0$  implies that stocks are bought and  $\Delta_{irt} < 0$  implies that stocks are sold during the period). Solving this optimisation program leads to the complementary conditions:

$$P_{irt} + k_{rt} \geq \frac{\hat{P}_{irt+1}}{(1+r)} \quad \perp \quad ST_{irt} \geq 0 \quad (5)$$

This equation is the standard relationship explaining stockholding behaviours (Williams and Wright, 1991): if the cost of buying goods at time  $t$  and storing them during one period is lower than the (discounted) price at which these goods can be sold at time  $t + 1$ , stockholders buy goods thus increasing the current prices until an equality holds in the first condition of 5. On the contrary, if the cost of buying goods at time  $t$  and storing them during one period is higher than the price at which these goods can be sold at time  $t+1$ , stockholders sell their stocks thus lowering current market prices until the same equality is reached or until their stocks are null (an equality holds in the second condition of 5), in which case the market is in equilibrium even if an inequality holds. These considerations explain why stockholding behaviours come to mitigate market price volatility, and also why sudden price peaks can occur in case of null stocks.

Furthermore, storing a commodity generates costs paid by stockholders and made up, for instance, of the rent of grain silos and of the wages of workers who carry out stock handling. In order to determine these factor incomes, a storage service sector is represented in the model. This sector uses labour and capital factors which are combined through a Constant Elasticity of Substitution (CES) function to produce the “storage service good”. Then, as for

the other goods, the zero profit condition in this sector allows to endogenously determine the price of the storage service which corresponds to the unitary storage cost. Moreover, as capital stocks are subject to adjustment costs, the storage capacity does not adjust instantaneously to stockholders' demand which places an upper limit on this capacity even if no storage bound is explicitly imposed. Finally, the market equilibrium conditions determining market prices includes beginning-of-period stocks on the supply side and end-of-period stocks on the demand side. Stocks buying and sales thus have an impact on equilibrium market prices.

## 2.4 Execution of the model

The model is solved iteratively, period by period, because agents readjust their decisions at each period, and in two steps for each period. This sequencing of the model resolution deserves some explanation.

As we already mentioned, consumers and producers base their decisions on expected future market prices. Furthermore, contrary to other agents, farmers do not observe market prices at time they take their production decisions. To take this specific feature of agricultural sectors into account the model is solved in two steps: in a first step agricultural production decisions are taken, based notably on farmers' expectations about market prices. At this time the prices of factors used for agricultural production adjust to ensure the equilibrium between farmers' demand and factor owners' supply. In a second step, agricultural quantities produced are sold, consumption, savings, investment and stockholdings decisions are taken, and prices of goods and factors allocated to non agricultural activities adjust so as to ensure the market equilibrium. If a productivity shock occurs after agricultural producers have decided how much to produce, then the quantities effectively produced are not equal to what farmers had expected. On the other hand, the other economic agents observe the market conditions and thus know current market prices at time they take their decisions. In the first step, determining agricultural production decisions, the model is thus solved by considering exogenous price expectations of producers, instead of endogenous market prices, and expected productivity values ( $E[\Phi shock_{ir}] = \Phi_{ir}$ ). The outcome of this first step corresponds to what agricultural producers plan and thus determines the level of production factors they use. The real agricultural supply can then be computed using the production function (Equation 3) and the "real" productivity values ( $\Phi shock_{irt}$ ). In the second step, the model is solved by considering the levels of agricultural factors and agricultural supply as exogenous. The outcome of the model corresponds to what effectively happens on markets, and notably determines the market prices, the

levels of investment and the stock buying or selling. In the next period, the first step is re-executed by taking into account the new levels of stockholdings and capital stocks, resulting from the previous period decisions, and the new expectations of agricultural producers. The second step is re-executed by taking into account the new producers' plans and the new agricultural supply levels. And so on.

### 3 Data and simulations

As already mentioned, the model we use is based on the GTAP AGR framework. We have already detailed the modifications brought to the GTAP AGR model to introduce dynamic behaviours and to account for private storage. Yet, some other differences with the GTAP AGR framework deserve some explanations. These concern the GTAP database, the calibration of parameters and the modelling of CAP instruments. Before turning to the simulation results, we therefore describe these particular features of our framework. We also devote the last part of this second section to the definition of simulations.

#### 3.1 Data

To run our simulations, we use the 6th version of the GTAP database calibrated on 2001 economic flows and including tariffs, export subsidies and direct payments for the different region represented. These data are aggregated to 12 sectors, among which 7 are agricultural sectors, and 3 regions: the European Union (EU), the United States (US) and the Rest of the World (RoW).

As the GTAP database was initially aimed at being used in a static framework to simulate long term effects, we need to make some assumptions to calibrate the data for our dynamic model. Here again we follow Femenia (2010) and assume that the initial interest rate  $r$ , the time preference parameter  $\rho$  and the unit capital installation cost  $\phi$  are all equal to 5%. This, along with the assumption that the economy is initially in a steady state, allows the calibration of all dynamic parameters. Furthermore, we reduce by half the supply price elasticities in agricultural sectors to account for the fact that agricultural supply adjusts more hardly in the short term than in the long term. Finally, the expectation adjustment parameter  $\alpha$  is set to  $1/5$ .

Then, we introduce wheat stockholdings in the three regions. As the economy is assumed to be initially in a steady state, private stockholdings are initially nil. However, the CES form of the production function in the storage service sector does not allow for zero production. To overcome this

issue we also assume that some precautionary wheat stocks, representing 10% of wheat production, are held by the public sector in the three regions. These precautionary stocks are constant over time and have thus no effect on price volatility.

### 3.2 Modelling of the CAP instruments

Our main objective is to simulate the effects of a storage subsidy on the market volatility induced by the removal of CAP instruments in arable crops sectors. To do so, we need first to simulate this volatility as accurately as possible. Yet, in the standard GTAP AGR framework the modelling of CAP instruments, notably in the arable crops sectors, suffers from some drawbacks (Femenia and Gohin, 2009b).

Firstly, in the GTAP database the 15 EU members (in 2001) are aggregated to one region but the EU intra-trade flows are maintained. Accordingly, quantities traded between EU members are supposed to be imports (or exports). Yet, a two-stage Armington trade modelling, where goods are differentiated by country of origine, is adopted: The composition of total demand from imports and domestic products is determined in a first stage, and the second stage determines the import shares from different origins, the substitution elasticity of the second nest being twice as high as those of the first nest. As goods traded between EU countries are considered as foreign goods, they substitute with non-EU imports in the second nest. The substitution facilities between non-EU imports and EU domestic products are thus higher than they should be. Now, trade elasticities have very large impacts on the welfare effects of trade liberalisation (Valenzuela et al., 2008). To avoid such misleading results, we therefore follow Femenia and Gohin (2009b) and transfer the EU intra-trade to domestic consumption.

Secondly, in the GTAP framework, arable crop direct payments are modelled as a land subsidy. They thus work as a subsidy to a fixed factor and are implicitly assumed to be capitalised in land values. They consequently have few impacts on inputs allocation and are not very distortive; the welfare gains induced by their removal are thus usually quite limited. Yet, as pointed out by Gohin (2006), the assumption that direct payments are capitalised in land values is contradicted by observed statistics on land rental rates. To overcome this issue we again follow Femenia and Gohin (2009b) and implement the specifications developed by Gohin (2006) in our framework. Namely, we assume that these arable crop payments are partly land subsidies, partly labour subsidies and partly capital subsidies. The set-aside policy linked to the direct payments is also taken into account in our simulations.

Finally, and most important when dealing with the impacts of the CAP

on market fluctuations, is the way variable export subsidies and tariffs are introduced in the standard model. Indeed, these instruments are key elements of the European price support scheme in the wheat and other cereal sectors. Yet, in the GTAP model they are represented as *ad valorem* instruments, and thus do not adjust to support domestic prices and insulate European from world markets as they do in reality. To account for the effects of these instruments on agricultural market volatility, we therefore change their modelling: we introduce both of them as endogenous variables which adjust so as to keep unchanged imported quantities (for variable tariffs) and domestic prices (for variable export subsidies) in the wheat and other cereal sectors.

### 3.3 Definition of simulations

The simulations are conducted over 30 periods.

We first simulate a benchmark scenario in which there are no political changes. In that case markets volatility results from productivity shocks occurring each year in the wheat, oilseeds and other cereals sectors in all regions (EU, US and RoW). These exogenous shocks can lead agricultural producers to make mistakes when they anticipate forthcoming prices, thus also generating an endogenous volatility of markets. For each region and each sector, the 30 stochastic exogenous shocks affecting agricultural productivity are generated according to normal distributions  $N(0, 0.01)$  in the EU and the US, and  $N(0, 0.02)$  in the RoW to reflect the highest yield variability, due to climatic hazards for instance, in this large region. 3 regions  $\times$  3 sectors  $\times$  30 periods = 270 shocks are thus generated. Furthermore, to make sure that the results we obtain are not essentially due to some specificity of the generated samples, we run some Monte Carlo experiments and repeat the simulations using 50 different samples.

In a second time, we use the same 50 shock samples and simulate the effects of a removal of the CAP instruments in the wheat, oilseeds and other cereals sectors. Namely, we remove the import tariffs, export subsidies and direct payments, and increase by 5% the land endowment in these sectors to reflect the removal of the set-aside policy linked to the direct payments. This policy reform is implemented gradually from the 3rd to the 6th periods. Indeed, it has been shown by Femenia and Gohin (2010) that, when agents have adaptive expectations, a gradual implementation of a radical reform, such as this one, is preferable to an immediate implementation, in terms of welfare effects. Comparing the results we obtain in this second step with those of the benchmark scenario, we will thus be able to characterize the changes in arable crops markets volatility induced by the CAP reform.

Finally, in a third time, we simulate the effects of the same CAP reform

along with a private storage subsidy which is set up at the end of the CA reform (at the 6th period). This subsidy is introduced in the RoW *via* a subsidization of 80% of the production of storage facilities<sup>1</sup>, which will lead to a price decrease in the storage service sector, and thus to a decrease of the storage costs.

## 4 Results

Before turning to the simulation results, we must make it clear that, for some of the 50 samples, one or more of the simulated scenarios lead to diverging dynamic systems. This is not very surprising. Indeed, even if many feedback effects represented in our CGE model decrease the occurrence of diverging cobwebs (Femenia and Gohin, 2009a), they do not totally eliminate them. We have thus chosen to remove the “diverging” samples, which reduces to 28 the total number of samples used in our analysis.

### 4.1 Benchmark scenario

Table 1 below reports the standard deviations of output, price and farm income in the EU, the US and RoW simulated with our model in the benchmark case, that is to say when no changes in agricultural policies are implemented. The figures reported in the table are the mean values of the 28 standard deviations simulated with the different productivity shocks samples. As our main concern will be, in the remaining parts, to study the expediency of subsidizing private storage, we focus yet on the effects of private storage and thus report the results corresponding to a situation without private storage (in the left part of Table 1) and those obtained when private storage is introduced in the model (in the right part of Table 1).

In this benchmark scenario, the market volatility is only due exogenous shocks arising in all regions and to the expectation errors made by agents when they take their decisions.

It appears that even if the volatility of exogenous disturbance is quite limited, with standard deviations equal to 0.01 in the EU and the US and to 0.02 in the RoW, the volatility of output can be twice higher. This is so because of the endogenous aspect of fluctuations in our model. Indeed, at each period the stochastic disturbances lead agricultural supply and market prices to be different from what agricultural producers had expected, which conduct them to re adjust their price expectations and so their production

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<sup>1</sup>Different rates of subsidy have been tested and the conclusion of the study remain the same

Table 1: Mean Standard Deviations in the Benchmark

		Without Storage			With Storage		
		EU	RoW	US	EU	RoW	US
Output	Wheat	0.02	0.03	0.02	0.02	0.03	0.02
	Oilseeds	0.02	0.03	0.02	0.02	0.03	0.02
	Other Cereals	0.01	0.03	0.01	0.01	0.03	0.01
Price	Wheat	0.03	0.10	0.10	0.02	0.09	0.09
	Oilseeds	0.13	0.13	0.13	0.13	0.13	0.13
	Other Cereals	0.00	0.09	0.06	0.00	0.09	0.06
Farm Income	Wheat	0.10	0.15	0.07	0.09	0.12	0.06
	Oilseeds	0.27	0.15	0.19	0.27	0.15	0.19
	Other Cereals	0.04	0.12	0.06	0.04	0.12	0.06

decisions at the next period. This endogenous source of output volatility thus comes in addition to, and is also sustained by, the exogenous shocks.

The standard deviations of prices are even higher in the RoW and the US, between 0.13 and 0.06 without storage depending on the sectors. This is notably due to the inelasticity of the demand for agricultural products and the rigidity of their supply in the short run which makes prices very sensitive to supply changes (as formalised by the King's law). The price volatilities of wheat and other cereals are however much lower in the EU than in the other regions (0.03 instead of 0.10 for wheat and 0.00 instead of 0.09 or 0.06 for other cereals). These figures illustrates the price stabilizing role of the European price support scheme and, in particular, of the variable export subsidies and tariffs. On the contrary, in the oilseeds sector, which is much less protected, the standard deviations of prices are equal to 0.13 for all regions.

Then, in addition to the volatility of output and price, we have chosen to report in Table 1 the standard deviations of farm incomes. Indeed, even if most of the studies dealing with agricultural market risks focus on output and price fluctuations, what matters to farmers is the stability of their incomes. Yet, if prices and outputs are negatively correlated, price fluctuations can compensate output fluctuations and thus, in a sense, provide a form of income insurance for agricultural producers. With standard deviations of income ranging from 0.04 to 0.27, this is obviously not the case here.

Finally, when stockholding behaviours are introduced in the model, the price and farm income volatilities in the wheat sector are lower in all regions. This observation comes to confirm the results of Femenia (2010) who shows that, even if economic agents have imperfect expectations, private stockhold-

ing behaviours allow to stabilize markets.

## 4.2 CAP removal

Having described the main characteristics of the volatility on agricultural markets in the benchmark case, we now get interested in the effects of a complete CAP removal in the wheat, oilseeds and other cereals sectors on this volatility. However, before turning to this central issue in our paper, we describe the long term effects of this radical policy reform.

The mean effects of the CAP reform observed over the last 5 simulation periods are considered as long term effects. Their mean computed, over the 28 samples, are reported in Table 2. Here again, we distinguish the cases with and without storage in the wheat sector.

Table 2: Long term effects of the CAP reform (%age changes compared to the benchmark)

		Without Storage			With Storage		
		EU	RoW	US	EU	RoW	US
Output	Wheat	-18.7	2.0	2.4	-16.1	1.4	2.0
	Oilseeds	-7.6	0.6	0.5	-6.4	0.3	0.6
	Other Cereals	-13.4	0.8	0.7	-11.8	0.8	0.5
Price	Wheat	9.9	0.7	1.4	10.1	0.7	1.4
	Oilseeds	6.6	0.3	0.5	6.6	0.3	0.5
	Other Cereals	13.6	0.4	0.5	13.6	0.3	0.5
Farm Income	Wheat	-64.6	3.4	6.9	-64.7	3.2	6.8
	Oilseeds	-36.1	1.0	1.4	-36.1	1.0	1.4
	Other Cereals	-58.3	1.4	2.2	-58.3	1.4	2.2

The effects on output, price and farm income of the removal of CAP instruments in arable crops sectors are in accordance with those commonly found in the economic literature. Indeed, without storage, the suppression of tariffs, export subsidies and, above all, direct payments in the EU induces a decrease of production in the wheat (by 18.7%) and other cereals (by 13.4%) European sectors. The production drop is smaller (-7.6%) in the European oilseeds sector because direct payments are initially smaller in this sector and there is no tariffs nor export subsidies. This production decrease induces a prices increase by 9.9% for wheat, 6.6% for oilseeds and 13.6% for other cereals. Overall, the price increases does not compensate the production decreases and EU farm incomes are negatively impacted by the reform: they increase by 64.6.5% in the wheat sector, by 36.1% in the oilseeds sector and

by 58.3% in the other cereals sector. In the US and the RoW the production increases in the 3 sectors to compensate the decrease of EU exports, due to the removal of export subsidies and the decrease of production, and to satisfy the increase of EU imports due to the tariffs removal. Then, because of the world prices increase induced by the increase of imports and the decrease of exports from the EU, prices slightly rise in these regions (between 0.3% and 1.4%). The production and price increases lead to increase of farm income in the US and the RoW.

Table 3: Welfare effects of the CAP reform (Equivalent variation in income, 2001 US\$ million)

Without Storage				With Storage			
EU	RoW	US	Total	EU	RoW	US	Total
25255	-6097	419	19576	25231	-6004	463	19691

Table 3 reports the welfare effects of the reform in the three regions. The figures reported in this table correspond to the discounted sum, over the 30 simulation periods, of the mean equivalent variations of household incomes in US\$ million. The welfare effect in the EU is highly positive with a total effect over the 30 periods of around 25 US\$ billions. This positive effect is essentially due to the additional disposal income induced by the suppression of the removal of the CAP. In the RoW, which is the main trading partner of the EU and thus the main beneficiary of the European export subsidies, the increase of agricultural prices induces a welfare loss which amounts to 6 US\$ billions. In the US the additional value added in agricultural sectors comes to mitigate the price increases and allows the welfare effects in the US to be positive, even if rather small (0.4 US\$ billion over the 30 periods). Globally, the world welfare impact is positive at the world level.

As shown in Table 4, the effects of the CAP removal on price fluctuations in the EU are unambiguously positive: the mean standard deviation of the EU prices increase from 0.03 to 0.10 for wheat, from 0.13 to 0.14 for oilseeds and from 0.00 to 0.07 for other cereals, in the simulations without stockholdings (the magnitude of the effects being almost the same with stockholdings). This is not surprising, since the public instruments protecting European markets from world price fluctuations have been removed. The increase of price volatility is besides much more important in the wheat and other cereals sectors than in the oilseeds sector which was less supported before the reform. Furthermore, output fluctuations also increase in the EU following the reform. This can be explained by the endogenous dimension of the volatility represented in our model: the destabilization of prices induces

Table 4: Mean Standard Deviations after the CAP reform

		Without Storage			With Storage		
		EU	RoW	US	EU	RoW	US
Output	Wheat	0.06	0.03	0.02	0.06	0.03	0.02
	Oilseeds	0.04	0.03	0.02	0.04	0.03	0.02
	Other Cereals	0.04	0.03	0.01	0.04	0.03	0.01
Price	Wheat	0.10	0.10	0.10	0.09	0.08	0.08
	Oilseeds	0.14	0.13	0.13	0.14	0.13	0.13
	Other Cereals	0.07	0.09	0.05	0.07	0.09	0.05
Farm Income	Wheat	0.19	0.14	0.07	0.18	0.12	0.07
	Oilseeds	0.19	0.16	0.19	0.19	0.16	0.19
	Other Cereals	0.16	0.11	0.06	0.16	0.11	0.06

a destabilization of agricultural producers' price expectation, and so a destabilization of their production. The EU farm incomes are thus also destabilized in the wheat and other cereal sectors, but not in the oilseeds sector where the standard deviation of income decreases from 0.27 to 0.19. In fact, the liberalisation of EU markets tend to "reconnect" the oilseeds sector to the initially highly protected wheat and other cereal ones. The market fluctuations in the three sectors are thus more related after the reform than before which benefits to the oilseeds one. The same kind of mechanism explains why price volatility of wheat and other cereals are reduced in the RoW and the US after the CAP removal. The transfer of risk from protected markets to world markets has besides often been used as an argument in favour of a liberalisation of agricultural markets (see Tyers and Anderson (1992) for instance). However, we must acknowledge that these reductions of price volatility are very limited, and that almost no reduction of output, neither farm income, fluctuations are observed. This is probably, once again, due to the endogenous source of market volatility represented in our model: following the reform expectation errors of European agents spread to foreign markets and come to increase the endogenous fluctuations on these markets. This last phenomenon partly compensates the decrease in volatility induced by the CAP removal.

Focusing now on the effects of private wheat storage on our simulation results, we can first notice that the production effects of the CAP removal are slightly reduced in all sectors. The EU wheat production now decrease by 16.1%, compared to 18.7% when no private stocks are held before and after the reform; and the RoW and US wheat productions respectively increase by 1.4% and 2.0% compared to 2.0% and 2.4% without storage. This can be

explained by considering the price volatilities after the reform, reported in Table 4. Indeed, as we have seen, whether private wheat storage is introduced or not, the CAP removal induces an increase of the standard deviations of EU prices in the wheat, oilseeds and other cereals sectors. Yet, the more prices fluctuate the more the private storage activity is stimulated. So, when stockholding behaviours are represented in the model, wheat stockholdings in the EU increase after the reform. In fact, as reported in Table 5, wheat stocks are nil before the reform, whereas the mean wheat quantities held by stockholders at each period reach 0.8 millions of tonnes after the reform. This new stockholders' demand for wheat thus comes to mitigate the wheat production decrease induces by the CAP reform. The opposite phenomenon arises in the RoW and in the US: the CAP removal induces a decrease of price fluctuations, which slows down the wheat storage activity in these regions (from 16.2 to 14.4 millions of tonnes of wheat stored at each period in the RoW and from 0.8 to 0.5 millions of tonnes in the US). The decreases of stockholders' demand for wheat have a negative effect on wheat productions which thus increase less when private storage is introduced in the model. The introduction of private wheat storage in the model also reduce, but to a lesser extent, the effects of the reform on the oilseeds and other cereal productions. The three sectors are indeed closely related, as inputs for the animal production for instance.

The differences between the effects of the reform on price and farm income levels, simulated with and without storage, are for their part very small. The only slightly significative effects of storage seem here to be a larger increase in the EU wheat price (10.1% instead of 9.9%) and a lower increase of the RoW farm income (3.2% instead of 3.4%) following the reform. The (relative) decrease of the RoW wheat farm income is easily understandable, since the introduction of storage has a negative effect on the production of wheat and the effect on wheat price is unchanged in this region. The relative wheat price increase in the EU is however more questioning. Indeed, private storage is usually found to have a decreasing effect on prices (see Williams and Wright (1991) or Femenia (2010) for instance). The increasing effect which seems to appear here is in fact due to the nature of the figures reported in Table 2: these are percentage changes compared to a benchmark cases. However the price levels simulated in the benchmark (not reported here) are already different with and without storage: they are lower when stockholding behaviours are taken into account. So, what seems to be a price increase due to the introduction of storage in the model is in fact the expression of the same price levels arising in the EU wheat sector after the CAP reform, whether storage is accounted for or not.

Finally, stockholding behaviours have a positive impact on world welfare

Table 5: Mean quantities of wheat stocks held by period (in millions of tonnes)

	EU	RoW	US
Benchmark	0.0	16.2	0.8
CAP reform	0.8	14.4	0.5

gains, which are 115 US\$ million higher with storage than without (see Table 3). These positive effects benefit to the RoW (93 US\$ million) and the US (44 US\$ million). On the contrary the EU welfare gains are reduced when private storage is taken into account (-24 US\$ million). An increase of private storage (as in the EU) thus seems to lower welfare gains, whereas a decrease of private storage (as in the RoW and the US) seems to increase them. This can be explained by the reduction of wheat quantities available for consumption and the increase of wheat price caused by an increase of stockholders' demand for wheat; and the increase of quantities available for consumption caused by a decrease of stockholders' demand. However, as risk neutrality is assumed in our model, these welfare effects do not acknowledge for the positive effect market stabilization could have on welfare if agents were risk averse.

### 4.3 Private storage subsidies

We have seen, in the previous section, that private storage has a positive effect in terms of global welfare and tends to limit the market fluctuations induced by the CAP removal. One can therefore presume that stimulating private stockholdings behaviours at the world level by subsidizing private storage could be beneficial. This is what we evaluate now.

We simulate the impacts of a 80% subsidization of production costs in the RoW storage service sector implemented at the end of the CAP reform. This induces a decrease of wheat storage costs at the world level and stimulates private storage: the mean quantities of wheat stocks held by period are now equal to 0.8 millions of tonnes in the EU, 24.9 millions of tonnes in the RoW, and 1.1 millions of tonnes in the US, that is a 67% mean increase world stocks.

The long term effects of this new reform are reported in Table 6 below. We can notice, on the one hand, that the introduction of the storage subsidy has almost no effect on productions. On the other hand, the price increases are now higher than with the CAP removal alone, especially in the wheat sector: the price increases following the reform are now equal to 10.3% in the EU, 1.0% in the RoW and 1.7%, compared to 10.1%, 0.7% and 1.4% with-

out the storage subsidy. Contrary to the previous (seeming) price increase observed in the EU wheat sector after the introduction of storage in the model (see section 4.2), these results cannot be explained by the nature of the figures reported here. Indeed, the benchmark cases compared to which these percentage changes are computed are the same for the CAP reform alone and the CAP reform and the storage subsidy. These results are thus surprising, since one would better expect a negative effect of the increase of stockholdings on wheat price levels.

Table 6: Long term effects of the CAP reform with private storage subsidies in the RoW(%age changes compared to the benchmark)

		EU	RoW	US
Output	Wheat	-16.1	1.5	2.1
	Oilseeds	-6.4	0.3	0.6
	Other Cereals	-11.8	0.8	0.5
Price	Wheat	10.3	1.0	1.7
	Oilseeds	6.7	0.4	0.6
	Other Cereals	13.7	0.4	0.5
Farm Income	Wheat	-64.6	4.0	7.4
	Oilseeds	-36.1	1.1	1.5
	Other Cereals	-58.3	1.5	2.3

Another surprising result lies in the volatilities observed in the wheat sectors. Indeed, the main argument in favour of a subsidization of private storage is that stockholding behaviours allow to stabilize agricultural markets. This is besides what we observed in the benchmark and the CAP removal scenario. Yet, as reported in Table 7, the standard deviations of wheat productions, prices and farm incomes are higher here than before the introduction of the storage subsidy. In the RoW, for instance, the standard deviation of output is now equal to 0.04, compared to 0.03 without the subsidy, the standard deviation of price is equal to 0.09, compared to 0.08, and the standard deviation of farm income is equal to 0.13, compared to 0.12. These differences are certainly small, but are in sharp contrast to what was expected from the subsidy.

In fact, a closer look at the results we obtain for a particular representative sample allows to understand the mechanisms at work here, and to explain both why the fluctuations on wheat market increase, and why the wheat prices increase, once the storage subsidy is introduced. We have reported the evolution, for that sample, of wheat prices following the CAP reform without (Figure 1) and with (Figure 2) the subsidization of private storage

Table 7: Mean Standard Deviations after the CAP reform and the set up of private storage subsidies in the RoW

		EU	RoW	US
Output	Wheat	0.06	0.04	0.02
	Oilseeds	0.04	0.03	0.02
	Other Cereals	0.04	0.03	0.01
Price	Wheat	0.09	0.09	0.09
	Oilseeds	0.14	0.13	0.13
	Other Cereals	0.07	0.09	0.05
Farm Income	Wheat	0.19	0.13	0.07
	Oilseeds	0.19	0.16	0.19
	Other Cereals	0.16	0.11	0.06

in the RoW. Figure 3 reports the evolution of wheat stocks in the world with and without storage subsidy.

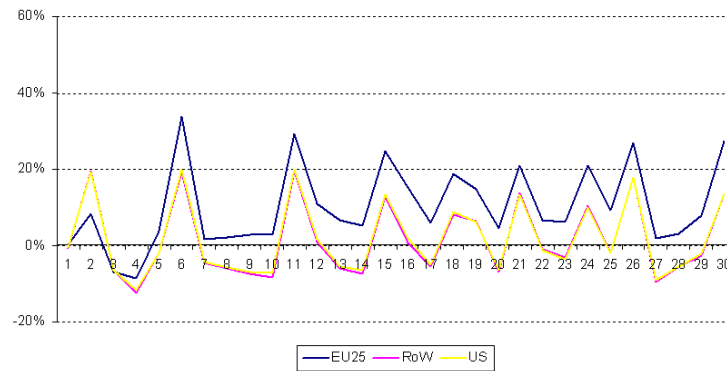


Figure 1: Evolution of wheat prices following the CAP reform, without storage subsidization (percentage change compared to the baseline)

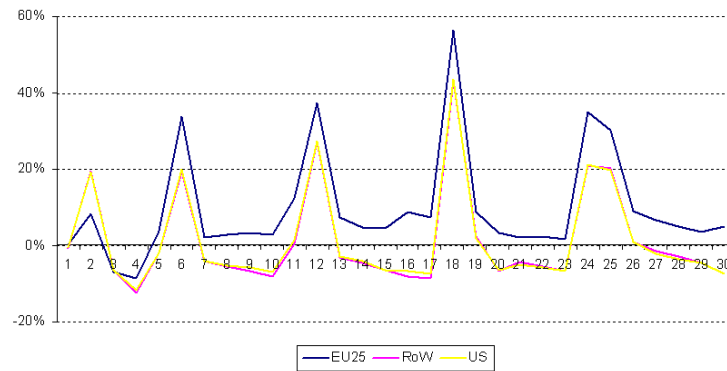


Figure 2: Evolution of wheat prices following the CAP reform, with storage subsidization (percentage change compared to the baseline)

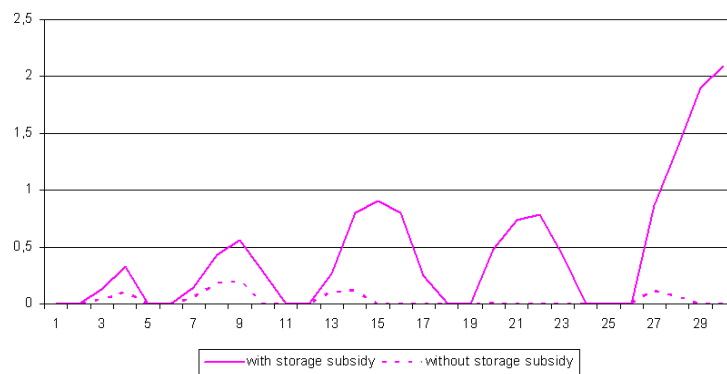


Figure 3: Evolution of wheat stocks in the world following the CAP reform, with or without storage subsidization (percentage change compared to the baseline)

What appears first, on Figure 1, is that, at the beginning of the simulations prices are identical with and without storage subsidy. However, from period 10, they start evolving differently: sudden price peaks are rarer but higher with the storage subsidy. As illustrated by Figure 3, these peaks correspond to stock shortages in both scenarios. These well known effects of stock shortages on prices are, in a sense, responsible for the increase in market volatility following the subsidization of private storage. Indeed, when storage is subsidized quantities of wheat stored by private stockholders are higher (see Figure 3), which can prevent some price increases, as in period 10 for instance: with the subsidy, world wheat stocks are sufficiently high to prevent the price increase due to a stock shortage that arises without the subsidy. However, the stock shortage effectively arises in the next period and its consequences on wheat prices are more important. The difference is that, with the subsidy, wheat producers, who have not observed the sudden price increase in period 10, expect a relatively low price for period 11, they thus plan to produce a relatively low quantity of wheat; as a negative productivity shock arise the quantities effectively produced are even lower, and since quantities of wheat stored are not, this time, high enough to satisfy the demand, stocks are completely cleared and wheat prices highly increase. On the other hand, without the subsidy, wheat producers who observed a price increase in period 10, plan a higher price for period 11 and thus produce more wheat which prevents wheat market prices to reach too high values. To sum up, when the storage subsidy is in place, wheat stocks, by preventing frequent price rises, eliminate these market signals and thus decrease the amount of information used by producers to take their decisions, which eventually gives rise to higher price increases. As a matter of fact, since, even if rarer, sudden price increases are higher with the storage subsidy, the standard deviation of prices are also are higher, and so are mean wheat price levels.

Table 8: Welfare effects of the CAP reform with private storage subsidies in the RoW (Equivalent variation in income, 2001 US\$ million)

EU	RoW	US	Total
24959	-6708	455	18707

Finally, Table 8 reports the welfare effects of the CAP reform with private storage subsidies. The welfare gains in the EU and the US are lower, and the welfare loss in the RoW is higher than when the CAP reform was implemented alone. As a consequence, the overall welfare gains decrease from 19691 US\$ millions to 18707 US\$ millions, which represents almost a 1 billion US\$ loss. This is in fact not very surprising regarding first the

huge increase in world wheat stocks which tends to decrease the quantities of goods available for consumption, and second the increase of mean prices of wheat following this reform.

The effects of the storage subsidy simulated here are thus globally negative, in terms of welfare first, but also in terms of market stabilization. As this subsidy tends to destabilize markets. The only (slightly) positive effect of the subsidization of private storage we find here is a relative increase of farm incomes in the wheat sector.

## Conclusion

Our main objective in this article was to study the effects of a subsidization of private storage on the volatility of agricultural markets following the removal of CAP instruments in arable crop sectors. Indeed, in the current context of agricultural market liberalisation, more and more attention is being paid to the need for a public intervention to stabilize these markets. Such an intervention could take the form of storage cost subsidies aimed at stimulating private storage at the world level. We have thus used a dynamic CGE model, taking into account the inter temporal dimension of economic agents' decisions, to study the impacts of a subsidy of wheat storage costs implemented in the RoW, both in terms of market stabilization and welfare effects. This model assumes that agents have imperfect expectations, which allows a representation of the endogenous source of market volatility. The exogenous source of volatility is also represented through the introduction of productivity shocks.

Our first results, concerning the effect of the removal of CAP instruments in the wheat, oilseeds and other cereals sectors, illustrate the effects of this reform on agricultural market fluctuations. Indeed, following the reform, the output, price and farm income volatilities increase in the EU, especially in the wheat and other cereals sectors where prices were highly supported (by variable tariffs and export subsidies) before the reform. On the contrary, the fluctuations on arable crop markets tend to decrease in the other regions (the US and the RoW). This comes from the suppression of the transfer of risk from EU to world markets initially induced by the EU price support mechanism. However this decrease of volatility observed on foreign markets is rather limited compared to the increase observed in the EU. As these simulations have been conducted with and without introducing wheat storage in the model, our results also reveal the stabilizing effect of stockholding behaviours on agricultural markets. We also show that an increase of the storage activity (as induced by the higher price volatility in the EU after the

CAP reform) tends to have negative effects on welfare. This can be explained by the negative effect of stockholders' demand on quantities of goods available for consumption. Turning then to the effects of the storage cost subsidy, we find that, whereas this subsidy effectively increase the quantities of stocks held at the world level, they do not have the anticipated effects on market fluctuations. Indeed, this subsidy, by increasing stocks, lowers the occurrence of stock shortages, and their associated price spikes. But this deprive economic agents, and farmers in particular, of the market information provided by these (moderated) spikes. Once these subsidies are set up, agents are thus less prepared to stock shortages that still (even if less frequently) arise. This eventually leads to very large price spikes, and so to larger market volatilities than without the subsidy. These subsidies do thus not prove to be efficient in terms of market stabilization. Furthermore, as they increase storage, they also generate welfare losses at the world level.

From the results of this study, it thus appears that, whereas private storage allows to stabilize agricultural markets, stimulating private stockholders' activity by subsidizing storage costs can in fact destabilize markets. According to these results, private storage subsidies should therefore not be considered as an instrument to stabilize agricultural markets after CAP reforms. We are however quite reluctant to draw too general policy conclusions from this study. Indeed, the potential risk aversions of economic agents have not been introduced in the model, yet this could change the outcomes of the model. Furthermore, the subsidy we have chosen to represent here is rather basic: it simply consists in a fix subsidy to production costs in the storage service sector. More elaborated ways to stimulate private storage at the world level, like subsidies adjusting market conditions, should certainly be considered before concluding that there are no incentives to publicly intervene in storage at the world level.

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