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# **Development of a computer system to support the AG-MEMOD composite model**

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## **Abstract**

The AG-MEMOD project is a 24 country partnership with the overall objective of providing a tool to simulate policy scenarios for about 30 commodity markets, for each year to a 10-years horizon, for the entire EU and for each country individually.

A computer system have been developed to combine the econometrically estimated models produced by each partners and to deliver an easily accessible and friendly set of results for the tested scenarios. The combined AG-MEMOD model is supported by Excel and Gams softwares and can be used without the need to enter the Gams code simply by implementing scenarios and viewing results in Excel spreadsheets.

The paper shows particularly how the information is structured in the system and how equations are encoded in the Gams interpretable language.

## **Keywords**

Multi-countries model, modelling tool, computer system, Gams, Excel

## **Introduction**

The EU AG-MEMOD composite model is an econometric, dynamic partial equilibrium, multi-product model with a country level disaggregation supported by publics funds from the Commission through the Fifth Framework Programme, and from Member States.

Originally based on the work of FAPRI-Ireland Partnership, the aim was to develop and to expand the European model (FAPRI GOLD Model) which runs in Excel and generates projections and simulations providing detailed country level result for 5 countries only. Considering the request of the Commission and the large number of partners (14 in the initial part of the project, 24 after the addition of partners from the New Members States) the main objectives were to produce a friendly tool, easy to share, with a high flexibility in order to be able to add new countries, new products or to change some specifications. The objective was to select the appropriate software in order that the solution is as accessible and as affordable as possible.

The aim of this paper is to show the technical solutions that have been created to combine the different country models, allowing them to keep their own specificities, and to produce an outcome able to generate results of policy scenarios at an EU level with the specific country level results. In this poster, we present the structure of the newly-built model, detailing the coding of variables and equations.

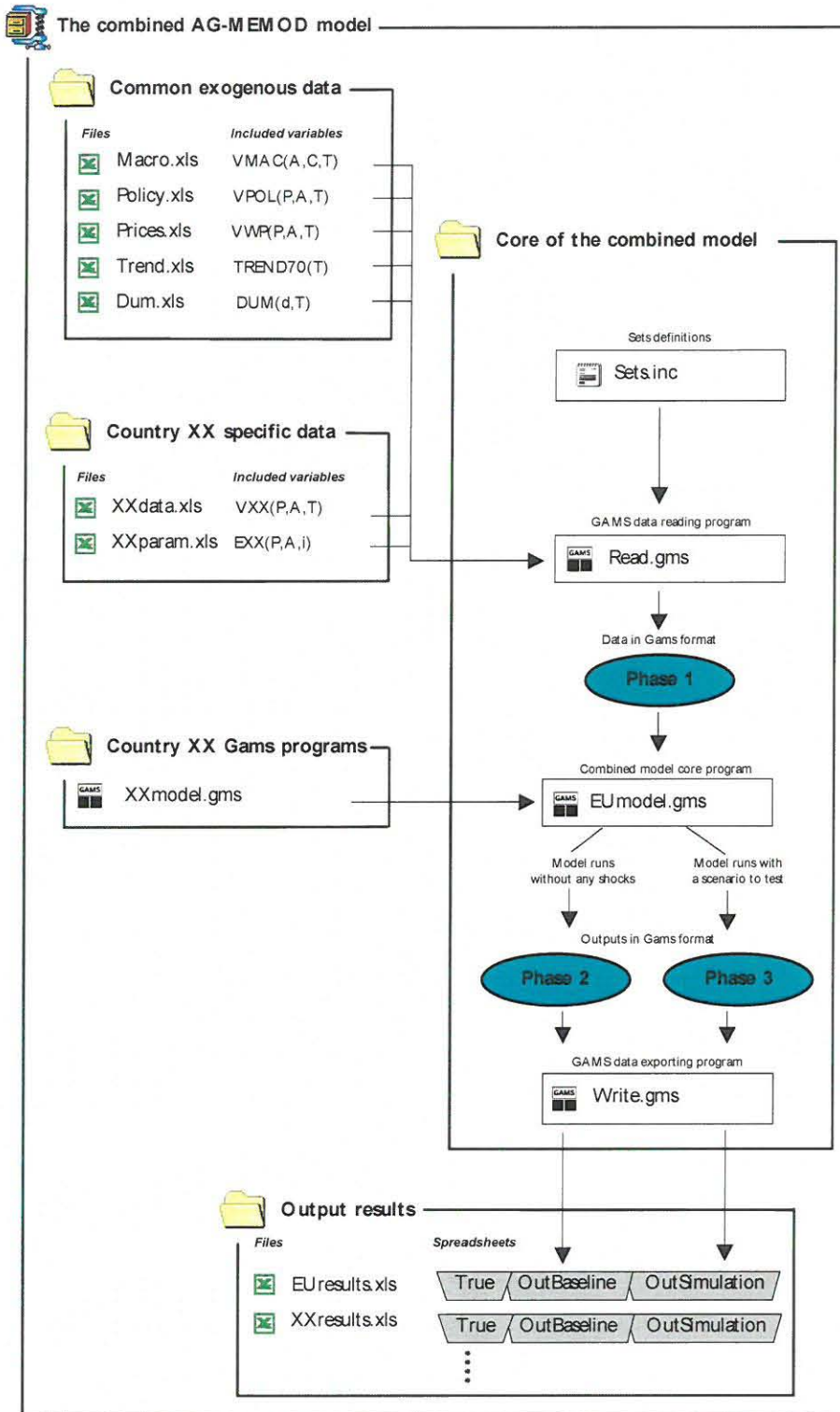


Figure 1 : Structure of the AG-MEMOD composite model

## **Country models characteristics and linkage principles**

In the partnership, every country has built its own model based on the FAPRI-GOLD model guideline (Hanrahan, 2001). Supply, demand, stocks and trades are econometrically estimated for every commodity markets. A commodity market must be balanced and closed at this country level, which will ensure the closure rule at the EU level.

The domestic prices are estimated using a key price and the self sufficiency ratio which are provided by the country that is the most important for a specific market. The world price is used by the main producer to estimate its domestic price or by individual countries when no key price can be found in the EU.

### **The software choice**

The software choice has been driven by practical considerations, notably the possibility to easily introduce:

- functional forms for behavioural equations
- exogenous data,
- behavioural parameters estimated separately by the partners,
- historical data for different countries for an easy presentation of outputs.

Following Advisory Group suggestions and for reasons of flexibility, our computer system is based on a combination of Gams and Excel software. Excel is used to store all types of data necessary for the model (data, behavioural parameters, dummies, etcetera) and to automatically receive all the outputs of the model. All kinds of data manipulations which allow a friendly presentation of the simulation results are then possible. Gams has been chosen for its relatively low price and its accessible language allowing a compact representation of large and complex models. Furthermore there are many ways to easily transfer data to Excel spreadsheets. Among these data transfer methods, a procedure developed by T. Rutherford is used.

### **The information structuring**

The model is structured as shown in figure 1.

A set of Excel files containing common exogenous data is stored in a directory. These data are written in different spreadsheets depending on their types:

- Macroeconomic variables : Gross domestic products (GDP), population, GDP deflator and exchange rates for all the EU countries modelled.
- Policy variables : intervention prices, subsidies and all policy variables for which the same level applies to all EU members.
- World prices.
- Trend and dummies, which are used sometimes in the equations, are defined in common and stored in two different spreadsheets.

For each country three files are delivered:

- An Excel spreadsheet containing all the country level data on commodity balance, commodity prices, policy variables (national quotas, reference yields, etc.).
- An Excel spreadsheet with all the estimated behavioural parameters.
- A file with the equations of each particular country model encoded in Gams code.

Three main Gams files then constitute the core of the combined model:

- A first file reads all the data, which are stored in Excel spreadsheets in a common directory and in all the country directories. Data are converted into a Gams specific format to be easily used by the main program. The definition of variables names, which

must follow a common Mnemonic, is represented in an isolated text file. Each partner has to use this file for reference to build its own country database.

- The main program that has to solve the combined model uses the data generated by the previous file. Programming elements are put in force to solve the model ensuring the links between the different country models are active. Outputs are exported in the Gams data format to be treated by the next file.

- The last Gams file is linked with the outputs of the combined model. Variables for the rest of EU are calculated if some countries are omitted from the combined model and results are exported in various Excel files

An Excel based output results file is created for each country and one is also produced for the EU as a whole. In each file are three spreadsheets with the same structure:

- The historical data is copied in the true data spreadsheet.

- If the model is solved without any shocks, results are exported in the baseline scenario spreadsheet.

- When the model is solved with a shock or a policy scenario, results are exported to the policy scenario simulation spreadsheet.

Other spreadsheets are created in the output Excel files to present results of the model in a graphical format or in pre-defined tables.

### **Data implementation**

One of the main issues is to ensure the consistency of the approach to data naming across all partners. Mnemonic have been developed for each kind of elements that is part of a variable name: Partners agree on specific names for country codes, commodity codes and activity codes. These codes are used in the Gams specific language to generate variables indexed with as many dimensions as necessary.

*i) Common variables : EU level policy variables, world prices and countries macroeconomic variables*

A policy variable which is common for all the countries takes the general name VPOL and is indexed with three dimensions: one for the commodity concerned, one for the type of policy instrument (activity code) and one for the time period. In this way, the soft wheat intervention price in 1996 can be noted as VPOL(WS,PIN,1996) and entered in the Excel spreadsheet for common policy variables with the first and the second dimension in a column and the third one in a row.

In the same way, world prices are named VWP. This variable needs three dimensions, such that the Corn world prices in 2002 which is the Maize US Gulf price in US\$/tonnes is noted VWP(CO,PMD,2002).

The third main type of common variables are country macroeconomic variables. They are named in a variable set called VMAC with three dimensions. Here the commodity dimension is unnecessary but is replaced with the country dimension. VMAC(POP,FI,1990) is the mnemonic for the population in Finland in 1990 in million people.

*ii) Country specific variables : data and estimated parameters*

Country specific data need four dimensions for their commodity, activity, country and time. In a first step, the country dimension is taken into account in the name of the variable because all the data for a country are stored in the same spreadsheet. For example, the soft wheat production in France in 1996 is stored in a spreadsheet called Frdata.xls with only three dimensions and is read as VFR(WS,SPR,1996). In a second step, after the importing phase, these variables can be renamed for

an easier data manipulation in Gams with a more general name considering the country as an index V(WS,SPR,FR,1996).

Behavioural estimated parameters are designed with a common name. The index is the same as that of the dependant variable but the time dimension is not needed and is replaced with an index which indicates the position of the estimator in the equation. For instance, in the soft wheat production in France equation, the constant take the name E(WS,SPR,FR,0), the parameter associated with the first explanatory variable takes the name E(WS,SPR,FR,1), and so on. As for country data, every partner deliver a spreadsheet with only three dimension, the country dimension is considered in the Gams data reading procedure. In our example EFR(WS,SPR,1) is read in the file FRparam.xls and the new name is given in a second step.

### *iii) Trend and dummies*

Some equations in country models use a time trend to represent technical progress or general tendencies. They can also use dummies to represent structural changes or particular events. These elements are entered as variables in two different Excel spreadsheets that are shared by the partners. It has been decided that when someone uses a trend in an equation, this trend begins in 1970 with the value of 0 and is increased by one for every year. The variable has then only one dimension, which is the time and is called TREND70(T). In 2000, the time trend is noted TREND70(2000) and take the value 30.

Dummies are considered with two dimensions: The first is an index to designate the kind of dummy, and the second is a time index. In this way, for example, a dummy to represent the structural change in Germany due to reunification in 1990 can be noted as DUM(D90,T) and takes the value 0 every year except in 1990 where its value is 1.

### **Encoding of equations in Gams code**

All estimated equations of the model could take this general form:

$$Y(t+I) = a_0 + \sum_{i=1}^n a_i * X_i(T) \quad (1)$$

with  $Y$ , the estimated variable,  $X$  an exogenous variable which could have an impact on the level of  $Y$ ,  $a_0$  the intercept element of the function,  $a_i$  the behavioural coefficient related to variable  $X_i$ ,  $n$  the number of explanatory variables,  $t$  the time and  $T$  which can be equal to  $t+I$  or  $t$  if the corresponding variable is a lagged one.

Consider the equation for Sunflower yields in France. It has been estimated as a function of:

$X_1$ : the French lagged price for sunflower divided by the French GDP deflator,

$X_2$ : A trend,

$X_3$ : A dummy (=1 in 1981, 0 otherwise)

$$Y(t+I) = a_0 + a_1 * X_1(t) + a_2 * X_2(t+I) + a_3 * X_3(t+I) \quad (2)$$

Following the Mnemonic, the previous equation can be written as:

$$UFYHAFR(t+1) = a_0 + a_1 * UFPFHFR(t) / GDPDFR(t) + a_2 * TREND70(t+1) + a_3 * D81(t+1) \quad (3)$$

with UF, the commodity code for sunflower, FR the country code for France, and with YHA, PFH, GDPD as respectively, the activity codes for Yield area harvested (in tons/ha), Domestic price (in national currency/100kg) and Gross Domestic Product deflator.

The writing of equation (3) into Gams is done as follows:

$$\begin{aligned} V2("UF","YHA","FR",T+1) = & e= \\ & EST("UF","YHA","FR","1") \\ & + EST("UF","YHA","FR","2") * V2("UF","PFH","FR",T) / VMAC("GDPD","FR",T) \\ & + EST("UF","YHA","FR","3") * TREND70(T+1) \\ & + EST("UF","YHA","FR","4") * DUM("D81",T+1) \\ & ; \end{aligned} \quad (4)$$

The code "V2" in equation (4) indicates that the variable is endogenous in the model and indicates that there is an equation for calculating this variable in the system. If an equation for a variable is omitted, an automatic assignment in the common part of the program gives the true value of this variable or gives the last known value from the historical data. This facility can be required when the model is solved with only a few countries and when a country that delivers a key price and its self-sufficiency rates has been excluded from the system:

Let's consider the pig meat price equation in the Spanish sub-model :

$$\begin{aligned} V2("PK","PRM","ES",T+1) = & e= \\ & EST("PK","PRM","ES","0") \\ & + EST("PK","PRM","ES","1") * V2("PK","PFE","DE",T+1) * VMAC("EXRE","ES",T+1) \\ & + EST("PK","PRM","ES","2") * V2("PK","PRM","ES",T) \\ & ; \end{aligned} \quad (5)$$

The Spanish pig meat reference price is a function of a constant, the German key price for pig meat expressed in €/100kg (carcass) and the lagged Spanish price.

If all country models are in the system, there is an equation in the German sub-model for calculating the German pig meat price as a function of an exogenous world price and policy variables such as subsidy export limits or tariff rate quotas:  $V2("PK","PFE","DE",T+1)$  is endogenous.

We have the possibility in our system to solve the model for only one country or any combination of countries. In a situation where the Spanish model is included and the German model excluded, the equations stay the same but an assignment automatically reassigns the pig meat price in Germany as an exogenous variable:  $V2("PK","PFE","DE",T+1)$  is then considered equal to  $V("PK","PFE","DE",T+1)$  which is read in the German country data spreadsheet and holds until the end of the simulation period with first credible estimation results.

## The running of the model and shocks implementation

One of the advantages of this computer system is that the user can produce projections and simulations to evaluate measures, programmes and policies without entering the Gams code.

Running the combined model to generate projections corresponding to a baseline scenario consists of successively running the three Gams files constituting the core of the system: the Gams file that reads data from Excel files (Read.gms), the Gams file that solves the system composed of the country models that the user has chosen to introduce (EUmodel.gms) and finally the Gams file that exports results in predefined spreadsheets (Write.gms).

Before running the first Gams file, common exogenous data have to be included in corresponding Excel spreadsheets out to end of the projection period. Then each Gams subprogram uses outputs of the previous one. On completion, outputs are stored in predefined Excel spreadsheets to produce the baseline.

Two possibilities are available to introduce shocks into the system:

The first one allows the user to modify directly the value of the variable that has been chosen to be shocked in the spreadsheet. For instance, consider the examination of the effect of a 70% partial decoupling of grain compensatory payments after 2005 for the entire EU. The procedure is to modify the value in the policy.xls spreadsheet where the variable VPOL("GR","COM",T) is stored for the corresponding years. The three Gams files have to be run again and results are exported in predefined spreadsheets to produce the simulation results in the same Excel files as those where the baseline scenario outputs are stored.

The problem here is that the original values used to build the baseline are then lost because they are replaced or overwritten in the original policy variables file. The alternative is then to introduce the shock in the beginning of the EUmodel.gms program by introducing this simple addition to the code:

```
GRCOMREF=VPOL("GR","COM","2005") ;  
VPOL("GR","COM",TE) = GRCOMREF*0.3 ;
```

TE is a time period corresponding to the 2005 to 2010 period and GRCOMREF is the name of a variable with the value of the grain compensatory amount in 2005 assigned. With this method the first program, which reads the data, does not have to be run again and the original data files are preserved.

## **Conclusion**

The computer system that has been developed to support the AG-MEMOD composite model is a satisfactory response to the project's initial objectives. The framework allows the planning, structuring and the combination of the works of many partners. It provides a flexible tool to produce simulations for agricultural commodities markets and it can be used by non-specialist users.

The actual tool consists of a compressed directory structure of 10,000Kb. A 30 years dataset is included for 14 countries, 30 commodities are modelled and more than 3000 equations are solved in the entire system. Two "common" and accessible software packages are necessary to fully utilise the system but Excel is sufficient for access to the database and for access to the simulation results that have been generated with the Gams solver.

The flexibility of the system allows the user to run a country model in a stand-alone format or in any combination of the countries available. The extension of the model to cover new countries, such as the new Member States, provides no particular computer related difficulties. Likewise the structure of the model means that the addition of new commodities can be achieved without any practical difficulty. In the same way, the updating procedure is relatively straight forward as the main tasks are



the updating of the Excel data files with recent historical data and/or new estimated parameters. The most important point is to employ equations that are as robust and consistent as possible in the country models.

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# Development of a computer system to support the AG-MEMOD composite model

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The EU AG-MEMOD composite model is an econometric, dynamic, partial equilibrium, multi-products model with a country level disaggregation.  
 The challenge was to develop a tool for combining 14 econometric country models, allowing the implementation of scenario reform projections at the EU level and for each member state.

## Model structure

### A common Mnemonic definition and data structure in Excel spreadsheets

- Variables are named depending on their type and indexed with as many dimensions as necessary following a common Mnemonic for Country (C), Commodity (P), Activity(A) and Time (T).
- Every type of variables is stored in independent Excel files.

Policy.xls						
	A	B	C	...	AR	AS
1	1973	1974	1975	...	2014	2015
2	WS	PIN				
...	...					

- The large database allows to simulate directly CAP reform scenarios and macroeconomics assumptions.
- A database with annual historical data since 1973 is used for each country.
- Partners deliver their estimated behavioural parameters in a separate file for an easier updating procedure.

### A friendly encoding of equation in Gams language

- Functional forms are encoded in Gams code. A Gams file is thus provided by each country.

Example: Gams encoding of the sunflower yield in France equation:  

$$V2("UF","YHA","FR",T+1) = e =$$

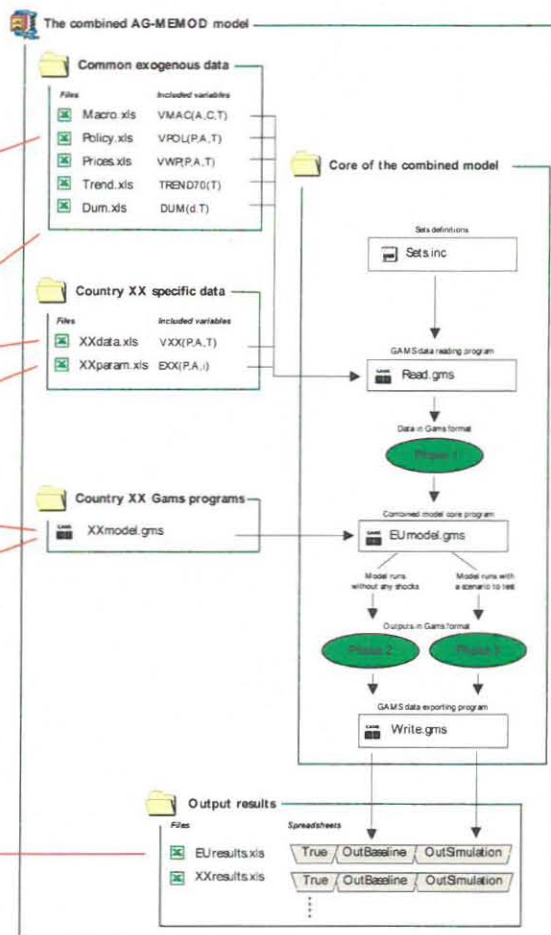
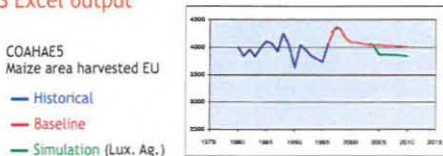
$$EST("UF","YHA","FR","1")$$

$$+ EST("UF","YHA","FR","2") * V2("UF","PFH","FR",T)/VMAC("GDPD","FR",T)$$

$$+ EST("UF","YHA","FR","3") * TREND70(T+1)$$

$$+ EST("UF","YHA","FR","4") * DUM("D81",T+1);$$

### Convenient visual data representations through MS Excel output



## Main results

- Each country model can be run as stand-alone or in any type of combination with a group of the other countries.
- No particular computer-related difficulty in updating and expanding of the number of countries and products.
- Several ways to introduce shocks and scenarios without entering the "black box" environment of the Gams program itself.
- A compact, clear, understandable and laptop-friendly system compressed in a 10,000 Kb directory.
- The current model version is a 30-year database for 14 countries, 30 commodities and allows the user to generate policy scenario simulations for each year up to a 10-year horizon.

