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AGMEMOD MODEL – STRUCTURE AND APPLICATION FOR ANALYSIS AND SIMULATION OF POLISH AGRICULTURAL SECTOR

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Abstract: The aim of this paper was to present the AGMEMOD[1] model as an example of partial equilibrium model applied in the field of agricultural economics and its capacity to evaluate changes in the Common Agricultural Policy (CAP). The AGMEMOD model is an econometric, dynamic, multi-product, partial-equilibrium modelling system constructed within the 5th and 6th EU Framework Project. As an example of application of the model a quantitative assessment of the impact of the milk quotas abolition on the Polish dairy sector was displayed.

Keywords: partial equilibrium modeling, simulation, agricultural policy analysis, milk quota

INTRODUCTION

The agricultural sector is a part of economy which is strongly regulated, so in the last decades the use of economic models in relation to agricultural policy issues has increased substantially. The results of liberalisation of agricultural market and of planned agricultural policy reforms (for example 'Health Check' of the

[1] AGMEMOD is an acronym of the name of the project: Agriculture Member States Modeling. This research was supported by EU FP6 research funding, contract SSPE-CT-2005-021543, by contributions from the partners' institutes throughout the EU and through associated projects for the Institute for Prospective and Technological Studies (IPTS).
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CAP) need to be assessed. For a better understanding of the behavioural relationships underlying agricultural commodity markets and for forecasting in the agricultural sector a wide variety of methods are applied. Partial equilibrium (PE) modelling is one of the methods employed for the purpose of agricultural policy analysis. It allows to capture the most significant relations inside the sector, including the effects of applying different specific policy instruments.

The objective of the paper was to present the application of partial equilibrium models in the field of agri-food sector. As an example the AGMEMOD model was chosen. One of the most important reforms carried on currently by the European Commission in this sector is the dairy market reform. Therefore a simulation of milk quota abolition for the Polish dairy sector was performed and displayed as an example of the AGMEMOD model application.

The article is organised as follows: in the first part the general assumptions and structure of the AGMEMOD model are presented. In the second section the construction of dairy sub-model is considered with more details. Finally, in the last section the results of the simulation of dairy quota abolition are presented.

AGMEMOD MODEL STRUCTURE

The AGMEMOD model is an example of partial equilibrium models (PE) applied in the field of agriculture. PE models' main characteristic is that they concentrate on the isolated market, considering the rest of the economy as an unchanging background for the analysis of supply and demand in this particular market. When compared to general equilibrium models (GE), PE models are more limited in the sense that they cannot include the effects of dispersion of changes in the analysed market to other sectors of the economy. However they can be quite useful for a detailed examination of many particular factors affecting the behaviour of agents in this market, especially when the influence of these factors does not seriously affect sectors other that the one in question. Thanks to their detailed structure, they often include diversified policy variables and serve to study the effects of their changes. More about equilibrium models and their applications can be found in the paper by Tongeren and van Meijl [1999] as well as Tongeren et. all [2001]. The main features of PE models make them particularly suitable for modelling the agricultural markets, as this sector is subject to the influence of a large set of complicated policy instruments [Conforti 2001; Garforth & Rehman 2006]. Moreover, for many agricultural commodities the data in the form of complete and detailed trade balance sheets is accessible, which helps in the analysis of the equilibrium between supply and demand.

The AGMEMOD is an econometric, dynamic, multi-product, partial-equilibrium modelling system which was built in the aim to undertake a model-based economic analysis of the potential impact of policy or other changes in the agri-food sector of each EU Member State and the EU as a whole. It was constructed within the 5th and 6th EU Framework Project assuming as a main principle

that the participating institutions in each Member State would develop a part of the model describing the local agricultural sector. The country models are based on a structure common for all the EU countries and with common procedures for data collection, estimation and validation, but take into account local conditions and rely on the local experts' knowledge. Consequently, the AGMEMOD model works as a system of aggregated local models and is able to produce forecasts and scenario analyse of various policy and external conditions' changes for the Member States separately as well as for the entire EU [Donnellan et. all 2002; Chantreuil Hanrahan 2007]. The work in the project was inaugurated in 2001 by the institutions representing the Old Member States (OMS) and resulted in a coherent system of models able to produce the aggregated forecasts for the EU-15 [Hanrahan 2001; Chantreuil, Hanrahan 2007]. In the subsequent years, the project was extended to consecutive countries[2] willing to enter the EU (NMS), Poland among them[3]. The enlarged AGMEMOD model was then used to estimate the consequences of their accession to the local agricultural sectors[4].

Each particular country model consists of a set of sub-models of the main agricultural products: grains, oilseeds and the derived products, industrial plants, milk and dairy products, livestock and meat as well as some other, of lesser importance and more locally grown products. The variables entering in each sub-model represent consecutive positions in the balance sheet of each market. On the supply side the beginning stocks, production and imports are being considered and on the demand side the domestic use, exports and ending stock are modelled. For each product in each country also the respective domestic prices (market-clearing prices) are modelled. The equilibrium in each market is reached in the model also on the level of the whole EU. This implies that the EU net export variable is used as the closing variable at the EU level. The necessary condition for the model to be solved is that the equality between supply and demand in each market in each country must hold. The general structure of the model is presented in Figure 1.

Such a disaggregation of the agricultural sector to the specific markets as well as the decentralisation of the model allowed to introduce into the model the instruments of the CAP in a very detailed manner. The instruments range from market-specific (quotas, subsidies, production levies, coupled payments) to more general ones, such as decoupled payments. Their influence can be traced in each market separately and the specificity of the agricultural policy in each member

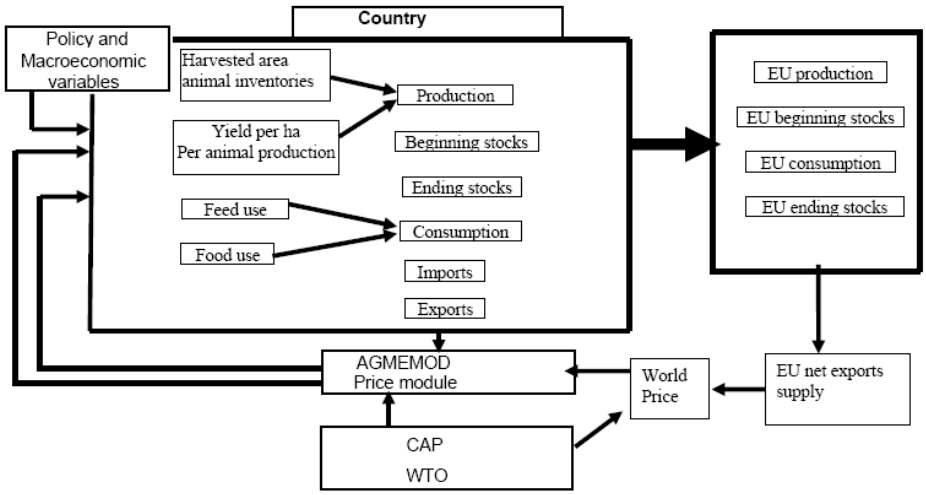
[2] At the moment, all the EU countries except Malta and Cyprus are represented in the model and the work is carried on to include also some Balkan countries, Russia, Ukraine and Turkey.

[3] The work on the Polish part of the AGMEMOD model entertained in the Warsaw School of Economics in 2002-2006 and since 2006 was carried on in the Warsaw University of Life Sciences.

[4] The influence of accession of Poland to the EU on the main supply and demand variables in the dairy sector was presented by Syczewska [2004].

state is taken into account. This huge advantage of partial equilibrium models such as AGMEMOD makes possible the analysis and simulations of a large spectrum of policy changes [AGMEMOD … 2005].

Figure 1. Structure of the AGMEMOD model



Source: Chantreuil F., Tabeau A., Van Leeuwen M. (2008)

In practice, the model contains endogenous and exogenous variables. The endogenous variables are mostly prices and the variables determining the supply and demand in the market of each product in every country. The exogenous variables include a set of variables describing the general macroeconomic conditions for the functioning of the agricultural market (GDP, inflation, exchange rates, population), world agricultural prices as well as CAP instruments. A change in exogenous variables may determine the assumptions of scenarios simulated by the model.

In the AGMEMOD model the equilibrium is reached in each market of each country independently. The characteristic feature of the model is that the price does not serve as a variable which would lead to the equality between the supply and demand in the separate market at a given moment of time, but is exogenous for the supply and demand variables at a given moment of time. Therefore one of the positions of the trade balance sheet, in most cases imports or exports, is treated as a *closing variable*.

On the country level, however, there exist interdependencies between markets of particular products. They result from the assumptions of substitution or complementarities between the products. The arable land allocation between different kinds of crops according to the relative profitability of their production can be given as an example of substitution. At the same time the use of different grains,

oilseeds and the derived products as fodder in the livestock production determines the relation of complementarity between crops and livestock.

As it was mentioned before, country market models are solved independently, nevertheless the behaviour of supply and demand variables in each member state market model is driven by a common factor, so called *key price* of this particular product. For each market included in the AGMEMOD model, the *key price* is the price of the product in the country which is its most important producer in the EU. In most cases, the country price of a given commodity depends on a simultaneous development of key price, lagged domestic and EU (or key country) self-sufficiency rates and other variables.

It is assumed that the EU is not a closed economy. The determinants of key prices include the respective world prices (which are exogenous in the model), the EU self sufficiency rate, the EU intervention prices and other variables important for the behaviour of key market prices (e.g. exchange rates, tariff rates, quota limits and subsidized export limits). To increase the economic integration between OMS and NMS, the process of price level convergence in the NMS to the EU (key price) levels is assumed [Chantreuil, Tabeau, van Leeuwen 2008; Esposti & Camaioni 2007].

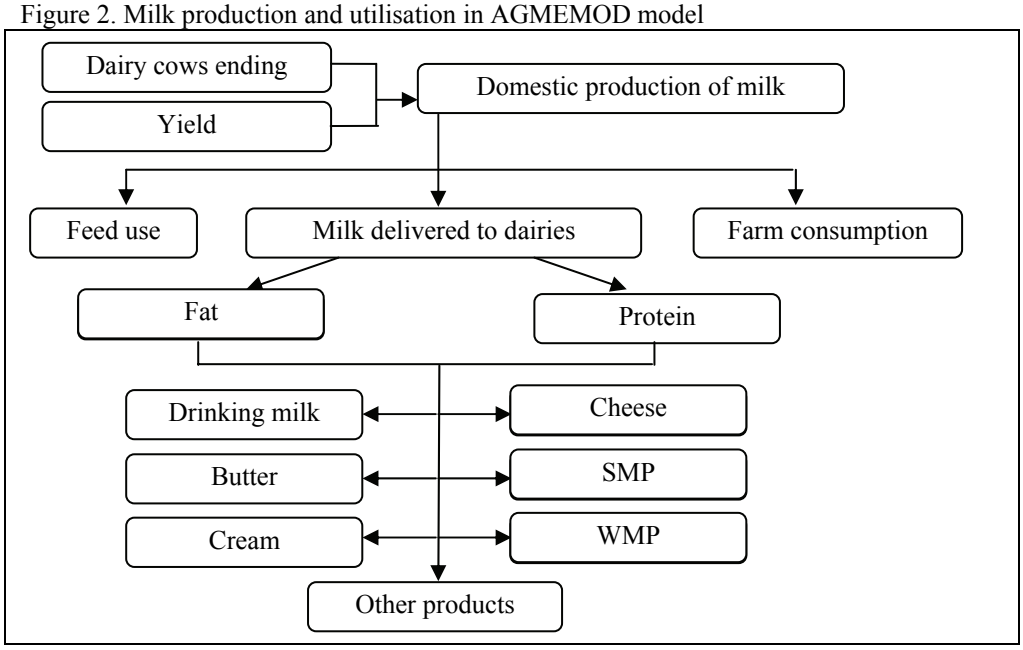
The behavioral equations of the model are mostly individually estimated with econometric techniques (generalized least squares). However, in situations where too short time series were accessible, the quality of data was unsatisfactory, important structural breaks (e.g. policy regime change) were observed or the estimation resulted in the values of parameters inconsistent with the economic theory (such as positive price elasticity of demand or negative reaction of domestic price to the key price), calibration techniques were used [AGMEMOD … 2005]. This last technique was applied especially in case of NMS allowing for reliable parameters estimation and consequently for a long term forecasting even thought relatively short time series. After the values of parameters were established, the model generated the baseline results. The validation played an important role in the construction of the model. Apart from general econometric tests on parameters and residuals, baseline results were analysed by national experts from the point of view of their feasibility. To check the reliability of the dynamics of the model a shock analysis were carried out.

DAIRY MARKET SUB-MODEL

Among the AGMEMOD market models, the dairy model is one of the most complicated. It comprises several components (Figure 2). The first component determines the production, import and export of raw milk (the last two are insignificant in Polish case), the second component allocates milk to different utilisations and the third component models milk use for further processing into dairy products [AGMEMOD ... 2005].

A particular feature of the dairy model is its emphasis on the allocation of milk fat and milk protein to the production of the various dairy commodities modelled (third stage). These products include drinking milk, butter, cream, cheese, skimmed milk powder (SMP), whole milk powder (WMP) and "other dairy products". For each dairy commodity modelled, the supply and utilisation is projected as well as the wholesale price.

Figure 2. Milk production and utilisation in AGMEMOD model



Source: own elaboration

The key variable of dairy sub-model is milk production. Generally it is modeled as a function of quota level and ratio between milk price and milk production cost. To model the milk production under the quota regime and non quota regime different equations are used because relations between price and level of milk output are dissimilar in both periods. Moreover, the long experience of many EU countries with milk quota made it impossible to assess econometrically the reaction of milk production to milk price changes (because of the distortionary role of milk production limiting). Thus some parameters concerning country-specific quota rents (marginal costs of production) were computed outside the model. Detailed description of methodology applied for estimation of milk production (AGMEMOD version 2.0) can be found in the paper by Chantreuil et. all [2008].

The milk yield per cow can be expressed as a function of technological trends, real milk prices, quota level and other exogenous variables that could have an impact on the milk yield per cow. The number of dairy cows at the end of a period can be derived as an identity involving the milk production and milk pro-

duction per cow. The milk price received by farmers is modelled as a function of prices of dairy products like cheese, butter, SMP, WMP.

As noted before, the AGMEMOD model allocates the fat and protein components of raw milk. The amount of fat and protein in the raw milk produced that is used in the manufacturing sector is first calculated. This calculation involves a number of assumptions concerning the fat and protein content of the raw milk and the fat and protein content of the dairy commodities produced out of milk. Once the available supplies of milk protein and fat have been calculated, the next step is to allocate the protein and fat components [AGMEMOD ... 2005].

Generally fat and protein allocation to different dairy products depends on the historical allocation, prices of a given commodity and prices of substituting commodities and other exogenous variables that affect their allocation. The total protein and fat available is allocated to n dairy commodities. The milk protein and fat allocation equations are estimated for $n-1$ products, with the milk protein and fats allocation to the n^{th} product derived as a balancing residual allocation. It is worth noticing that for a given commodity only one behavioral equation is applied (to estimate fat or to estimate protein). For example, fat for butter is behaviorally estimated while proteins are computed as an identity.

The production of a given dairy commodity is derived as the total milk protein or fats allocation divided by a technical protein and fat content in the product. The domestic consumption of a specified commodity is derived from a multiplication of the population number by consumption per capita. The consumption per capita of a given commodity is a function of GDP/capita, price of a given commodity, prices of substituting products and other exogenous variables affecting domestic consumption.

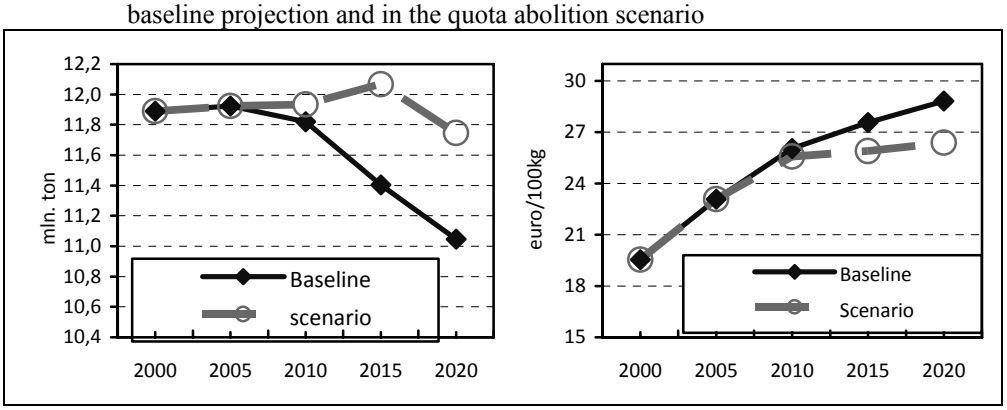
EXAMPLE OF AGMEMOD MODEL APPLICATION: MILK QUOTA ABOLITION IMPACT ON DAIRY SECTOR

Milk quotas were introduced in the European Union in 1984 in order to try to stop the over-production. In the so-called CAP "Health Check" the European Commission has recently proposed gradual transitional procedures to allow for a "soft landing"' of the milk sector to quota expiry in 2014/15 [CAP… 2008, Réquillart et. all 2008, Seremak-Bulge 2008]. The objective of this study is to perform an ex ante quantitative assessment of the impact of abolition of the EU milk quotas on the Polish dairy sector. The time period covered by the analysis is up to 2020. The impact of policy scenario was assessed and compared to a baseline scenario (that is considered to be continuation of the current quota system). The scenario assumes a gradual increase of milk quota by 1% a year between 2009 and 2014 and the removal of quotas since 2015.

It is commonly expected that the abolition of milk quota system would result in an increase of milk production and a decrease of prices of raw milk and prices of

dairy products [Seremak-Bulge 2008, Jongeneel, Tonini 2008]. The simulations carried with the use of the AGMEMOD model confirm those expectations. The rise of total production of raw milk as a result of milk quota abolition is evaluated at 1.0% in 2010, 5.8% in 2015 and 6.3% in 2020 (Figure 3).

Figure 3. Milk production (left) and milk prices (right) in Poland and their forecasts in the baseline projection and in the quota abolition scenario



Source: Own calculations on the base of Agmemod model

Going into details, diverse changes of milk use are noticeable as a consequence of the potential reform. The abolition of milk quota results in a greater production capability for the dairy industry. By 2020 there can be observed an 8% increase of milk delivered to dairies which is a base for industrial production of dairy products. The level of milk consumption on farms could become lower by 5% and the feed use can boost by nearly 6% at the same time.

The baseline scenario indicates further increase of milk prices paid to farmers. Firstly, this growth would be explained by the convergence of Polish milk price to the prices observed in the OMS. The second reason would be a decrease of self-sufficiency rates in individual markets of dairy products in the situation of a relatively fixed milk supply. In the quota abolition scenario the price of raw milk in 2020 is lower by 8.4% than the price in the baseline scenario (Figure 3). As a consequence of lower prices paid to farmers the production profitability would decrease. Going further, a faster concentration of milk production should be expected as a result of the deregulation of the dairy sector.

The changes in production, consumption and prices of in particular dairy markets are presented in the Table 1. The highest decrease of the wholesale price of dairy products is observed in the case of GOUDA cheese (10%) and the least decrease can be noticed in the case of whole milk powder (WMP) (7.4%). The changes in prices of the remaining products are situated between those two values.

The growth of 6.3% (in comparison to the baseline scenario) in the quantity of milk delivered to dairies results in a similar increase of the quantity of fat and

protein, which would also stimulate growth of production of dairy commodities (Table 1). The highest increase of production is expected in case of cheese (8.7%), butter (7.2%), and SMP (7.1%). The most modest growth of production is to be observed in case of drinking milk and WMP, respectively: 2.0% and 3.4%.

Table 1. Influence of milk quota abolition on dairy market in 2020 (changes with respect to the baseline projection)

Product	Changes in:		
	Production	Consumption	Prices
Raw milk	6.3%	-	-8.4%
Drinking milk	2.0%	1.3%	-
Butter	7.2%	2.7%	-8.4%
Cheese	8.7%	2.1%	-10.0%
SMP	7.1%	3.5%	-7.8%
WMP	3.4%	3.6%	-7.4%

Source: Own calculations on the base of Agmemod model

The expansion of supply and the reduction of wholesale prices of individual dairy products would have a positive effect on the domestic consumption of those commodities. The forecasted growth of consumption caused by the abolition of milk quota system varies between 1.3% in the case of drinking milk and 3.5-3.6% in the case of both sorts of milk powder. The adjustment of production and domestic use after a dairy market reform results also in the changes of the self-sufficiency rates of products considered. Generally, the milk quota abolition would cause a rise of those indicators.

CONCLUSIONS

1. Partial equilibrium models represent a suitable tool for analyzing the changes in agricultural sector due to the fact that agriculture is influenced by large set of policy instruments. PE models allow for a detailed analysis of their impact on particular elements of this market.
2. The AGMEMOD model allows for simulation and forecasting of a variety of policy scenarios for Poland as well as for the whole EU. Further development of the model should tend to endogeneisation of the world prices in the Rest of World sub-model.
3. The application of AGMEMOD model version 2.0 for an analysis of impact of dairy quota reform indicate an increase in production and consumption of dairy products and a decrease of their prices in Poland. The direction of changes are consistent with the a priori expectations.

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Model AGMEMOD – struktura i zastosowanie w analizie i symulacji polskiego sektora rolnego

Streszczenie: Celem opracowania było przedstawienie modelu równowagi cząstkowej AGMEMOD w kontekście modelowania sektora rolnego i możliwości ewaluacji zmian Wspólnej Polityki Rolnej (WPR). Model AGMEMOD zbudowany w ramach 5 i 6 Projektu Ramowego UE należy do ekonometrycznych, dynamicznych, wieloproduktowych modeli równowagi cząstkowej. Jako przykład zastosowania modelu i jego możliwości przedstawiono analizę wpływu likwidacji kwot mlecznych na zachowanie polskiego sektora mleczarskiego.

Słowa kluczowe: równowaga cząstkowa, modelowanie, symulacja, polityka rolna, kwoty mleczne