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PARTIAL EQUILIBRIUM MODEL AS A TOOL FOR POLICY ANALYSIS IN AGRICULTURE: AN EMPIRICAL EVIDENCE OF MACEDONIA

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Summary

Agricultural sector modeling based on partial equilibrium modelling of the supply and demand has become standard approach in the market outlooks and policy impact studies. The model builders and users reveal many pros and cons of the process and results of modelling. The Macedonian experience confirms some typical obstacles and at the same time faces some new ones with a local perspective. The paper provides a summary of the milestones in modelling the partial equilibrium model for the livestock-feed sector in Macedonia with main focus on the obstacles and limitations in the process. This experience is expected to be useful for the countries in the Western Balkan region planning to build a sector models based on partial equilibrium concept as a policy analysis tool.

Keywords: partial equilibrium agricultural sector models

JEL classification: *Q110*

1. Introduction

Models, as a simplified representation of a real situation by identifying the key factors and the relationship among, are sophisticated method for analyzing and solving real problems (Lee & Olson, 2006; Howitt, 2005; Garforth & Rehman 2006). They are used to explain certain events being observed and to improve economic theory as well. They are a good tool for building projections, simulation and 'what if' analysis, as well as a tool for assessing the impact of market-price measures on agricultural markets, or the changes in the internal and international market (Buckwell 1989; Erjavec and Kavcic 2005; Bienfield et al. 2001; Jensen et

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al. 2002). A range of models in terms of used method (general or partial equilibrium models, synthetic or econometric), subject of analysis (agricultural policy, trade policy, environmental policy, etc) or the geographical coverage (national, regional or global) have been developed through the last decades in agricultural economics (Bienfield et al. 2001; Lehtonen, 2001; Salvatici et al. 2001; Jensen et al., 2002; Erjavec, 2004).

The partial equilibrium models are comprehensive market models describing specific sub-sectors or groups of agricultural sub-sectors, analyzing in detail both sides of the equation between supply and demand, the price formation, interdependency of agricultural inputs and outputs between different product lines, the policy impact on supply and producers' income, etc. The general concept behind the model is the neo-classical approach by which the supply and demand rich their equilibrium while producers and consumers tend to maximize profits and product utility.

The partial equilibrium models forecasting the agricultural sector in Macedonia develop gradually. First, the partial equilibrium model for a single commodity (pig meat sector) was built. Since livestock production uses the crop production commodities and transforms them in other final or semifinal products, the interrelationship between the crop production and livestock production is of vital importance for the policy analysis (Halcrow, 1984). Hence, the interaction among livestock and feed sectors has been subject of forecast of three other multi-commodity partial equilibrium models: the comparative-static model, and two dynamic synthetic models. They are all academic documents, thesis and dissertations.

The aim of this paper is to provide a summary of the milestones in modelling the partial equilibrium model for the livestock-feed sector in Macedonia with main focus on the obstacles and limitations in the process. This experience is expected to be useful for the countries in the region planning to build a model as a policy simulation and analysis tool. Presenting all the limitations of the model, the paper also explain why a partial equilibrium model is chosen as a method for assessing the development of the Macedonian livestock-feed sector. More details about the model and it results can be found in Kotevska (2010) or Kotevska et al (2013).

2. Method

The method used to evaluate the future development of the Macedonian livestock-feed sector is a synthetic multi-commodity national partial equilibrium model. The model follows the general principles and structure of the AGMEMOD model (Salamon et al. 2008; Chantreuil et al. 2012). It is based on a set of multiproduct

linear regression analysis of certain elements in the food balance sheet for grains, meat and milk for the period from 1995 to 2008, producing projections up to 2020.

The model is composed of set of modeled and derived variables. Modeled variables are the commodity prices, production units (area in crop sub-models and breeding heads in livestock models), yield, consumption (per capita and for feed), and trade (export), as well as slaughter heads and slaughter weight in the livestock sub-model as intermediate-steps in production forecasting. The derived variables complement the picture of each market. They include the expected gross income in crop models, production, total consumption, import, net trade and self-sufficiency rate. Some of the modeled variables are used in others sub-models as endogenous variables, while others, some macroeconomic data, are taken or modeled outside the model as exogenous variables. The link with the external markets is through the price projections of the key agricultural markets from the combined AGMEMOD model.

For each individual commodity a sub-model is built, which is later integrated into a single model. The model includes seven commodities, grouped into three sub-models with similar structures. Thus, the grain group includes the wheat, barley and maize sub-models, the meat group includes beef, pig meat and lamb sub-models, and the milk sub-model covers the market of raw cow's milk, without taking into account its processed products.

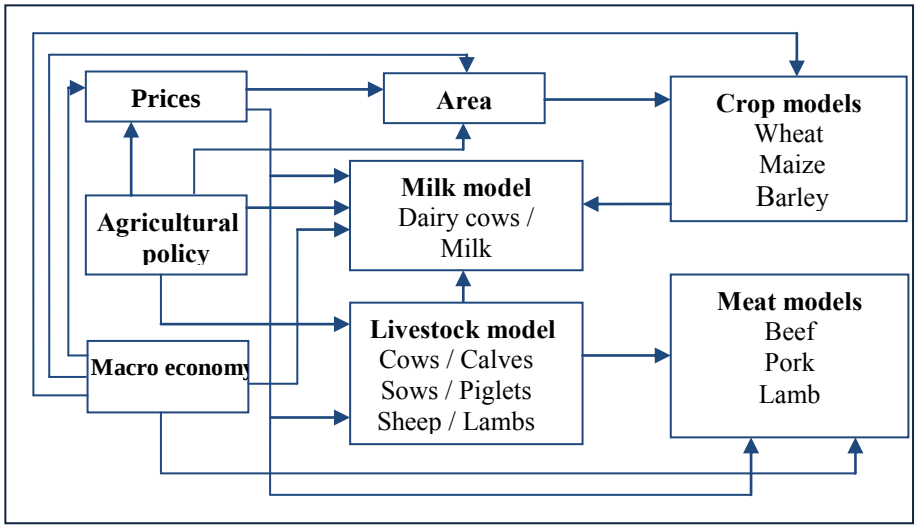

Figure 1 Sub-models interrelations

The linkages among sectors are presented in Figure 1. The crop models are linked through the distribution of total arable land used for crops, and their prices since they are substitute inputs in the livestock production. Crop models are additionally

linked through the use of grains as feed in livestock models. On the other hand, the volume of livestock production defines the demand of grains for animal nutrition. The linkage between meat models is by their relative price, assuming they are being partial substitutes. The milk model is linked with the beef model by the total number of cows.

The policy included in the model is structured by simplifying the method for harmonizing policy developed within AGMEMOD partnership (Salputra, Miglavs, & van Leeuwen, 2008). This system is set up to cover the recent reforms of CAP, distinguishing among different direct payment, regional and historical payments, as well as different national policy before accession and the topping up rates in the new member states. The allocation of agricultural budget in Macedonia to sectors and different measures is based on APM methodology (Rednak & Volk, 2010), and data from the national program for agricultural policy and rural development (MAFWE 2009). The integration of the agricultural policy in the model is through the calculated support (so-called reactive price) which by complementing the commodity market price affects the production decisions of farmers.

The assumptions behind the model are small country economy, free price formation, no changes in supply and demand factors, and stable macroeconomic indicators, such as real GDP and GDP deflator; population growth; and fixed exchange rate.

The model analyses four scenarios:

- The first, *baseline scenario*, assumes no EU accession, neither change in policy measures, but includes an increase of the budget for support of agriculture as planned and projected by the Ministry of Agriculture Forestry and Water Economy (MAFWE 2009).

- The second scenario, *price convergence scenario*, assumes EU accession in 2015 and price adjustment (appropriate increase or decrease) of the covered commodities due to the integration into the common European market.

- The third scenario, *EU–optimistic scenario*, assumes EU accession in 2015, price adjustment and application of CAP with an optimistic projections of budget volume and measures allowed (national ceiling as expected from MAFWE (2009); a topping-ups rate from the national budget, as in case with Slovenia in 2004; different levels of regional payments for pastures, arable land and perennial crops; coupled payments for beef and lamb; no historic payments).

- The fourth scenario, *EU–pessimistic scenario*, assumes EU accession in 2015, price adjustment and application of CAP with restricted budget and allowed policy measures (national ceiling is 75% of EU-OPT values; topping-ups from national budget is fixed at 30% in the period 2015-2020; regional payments are equal per unit capacity for arable land and pasture; no coupled and historical payments).

3. Limitations and problems of the Macedonian PE model

In the past, modelling the agricultural supply and demand is mainly done by explaining the past behavior while lately the main focus is in making projection on the future market development. Since the future is not known, modelling is performed on econometric analysis of the past data and on a bunch of assumptions. Thus, the success of gathering quality data and making good assumptions and consequently making good approximations of reality is the key factor affecting the usefulness of the model results.

4. Data requirements and statistics as limitation

The vast data requirements from one side and data availability from other side are weak points in modelling the Macedonian agriculture. In order to fulfill the quite demanding database required by the model, data used are from various sources: State Statistical Office (balance sheet, except trade), Customs Administration (trade), Ministry of Finance (historical data and future projections on GDP, GDP deflator and exchange rate), Ministry of Agriculture, Forestry and Water Economy (historical data and future projections on agricultural policy budget). The lack of available data is being supplemented by derivatives from available data (Table 2 and 3) as well as by including expert opinion and interdisciplinary collaboration for making enhanced adjustments and achieving data and results consistency.

Table 1: Grain balance sheet items and calculation

Item	Symbol	Unit	Source/Calculation
Area harvested	AHA	1,000 ha	SSO
Yield	YHA	t/ha	=SPR/AHA
Production	SPR	1,000 t	SSO
Import	SMT	1,000 t	SSO
Export	UXT	1,000 t	SSO
Consumption	UDC	1,000 t	=SPR+SMT-UXT
Feed consumption	UFE	1,000 t	=UDC*c
Food consumption	UFO	1,000 t	=UDC*c
Share in grain area	ASH	ratio	=AHA/GRAHA
Per capita consumption	UPC	kg	=UDC/POP
Self-sufficiency	SSR	ration	=SPR/UDC

c – Coefficient, according to an expert opinion
SSO = State Statistical Office of Republic of Macedonia, official data

Table 2: Livestock balance sheet items and calculation

Item	Symbol	Unit	Source/Calculation
Total number of heads	CCT	1000 heads	SSO
Number of female breeding heads	CCT	1000 heads	SSO
Number of slaughtered heads	KTT	1000 heads	*calculated**
Offspring crop	SPR	1000 heads	SSO
Production	SPR	1000 t	SSO
Import	SMT	1000 t	SSO
Export	UXT	1000 t	SSO
Consumption	UDC	1000 t	=SPR+SMT-UXT
Slaughter weight	SLW	kg/ head	=SPR/KTT
Weighted number of heads	WCI, WSI, WEI	1000 heads	$=0.8 \cdot CCT+0.2 \cdot CCT_{(-1)}$
Offspring (yield) per breeding head	YPC, UPS, YPE	heads	=SPR/CCT
Per capita consumption.	UPC	kg	=UDC/POP
Self-sufficiency	SSR	ratio	=SPR/UDC

SSO = State Statistical Office of Republic of Macedonia, official data

The partial equilibrium model is based on a regression analysis of items in the food balance sheet for the selected commodities (Table 2 and 3). Thus, the quality of the model is directly dependent on the data needed for fulfilling the food balance sheets.

By definition, the food balance sheet, as a comprehensive picture of the country's supply and demand for a certain commodity during a given reference period (OECD 2007), gives the total quantity of products produced in the country, added to the total imported quantity and the beginnings stocks on one side, and the exported quantity, the quantity used for livestock feeding and human consumption, as well as the ending stock on the other side.

Production + Import + Beginning stocks = Consumption + Export + Ending stocks

Data availability caused some difficulties in preparing the balance sheets. The most problematic in constructing Macedonian food balance sheets are the assessment of ending stocks, the commodity consumption, and the allocation of the feed among different livestock productions. None of them is covered by the national statistics.

The first have been resolved by the assumption that the country has small amount of ending stocks that overflow from year to year, and are being estimated as equal to zero in long run (Dimitrievski and Ericson 2010).

Regarding the commodity consumption, the state statistical office collects data about the household consumption, but not on public consumption and from food processing industries. Following the principle that supply equals demand, and assuming zero ending stocks, total consumption is calculated as a sum of production and import reduced for the amount of export. Hence, the consumption is an aggregate amount comprised of quantities used as unprocessed food, used in processing industry (for food), as feed, as seed, waste and loss.

Total consumption = Production + Import – Export

The allocation among different livestock productions was made on the basis on interdisciplinary collaboration on expert opinion from agricultural economists and animal nutritionists.

Balance sheets proved to be a good tool for noticing inconsistencies in the statistical data set. For example, when building the database on the Macedonian livestock sector, it was observed that the number of slaughtered heads didn't correspond with the production volume. A deeper examination reveals that the problem lays in the methodology of data collection. Namely, the number of heads sold to slaughterhouses for slaughtering was registered as 'sold' not as 'slaughtered'. In order to include those heads, but to avoid double evidence, the data were corrected by the calculation* of slaughtered heads as a sum of 'slaughtered heads' and 'sold heads', reduced by 'bought heads'. Another example is the small number of piglets per saw. The question in the questionnaire was ambiguous, not asking for the number of farrowing per year or the number of piglets per saw per year. A discussion with pig experts reveals that some share of small farmers has only one farrowing per year, and other small yielding saws. Still, it doesn't cover all pig population and doesn't give the correct picture on this issue.

The change of the policy regime initiated changes in the methodology of data collection in the statistical office. These cause another limitation for the model - the limited size of comparable data series of 13 years. When used for forecasting, the size of the time series makes a difference, because as Gold reports (in Allen 1994), series of 20 years give better results than do series of 15 or 10 years.

Concerning the problems in obtaining data, it is normal to expect problems in parameter estimation and model validation. To solve this issue, the parameters produced with the regression analysis are included in the model, and then calibrated, which makes the model synthetic rather than econometric. Calibration method or so-called 'synthetic approach' is used to "generate a set of parameters that is consistent with both the benchmark data and the theory underlying the

model" (Lehtonen 2001:42). The model validation is performed by sensitivity analysis of price changes and by extension of the projection period. The sensitivity analysis evaluates the influence that price changes have on the model behavior (results). By extending the years of projections, the viability of the model results is additionally evaluated.

5. Linkages as limitations

The partial equilibrium models are comprehensive market models because they analyze in detail both sides of the equation between supply and demand of specific agricultural sub-sectors, including the price formation and interdependency of agricultural inputs and outputs between different product lines. The presentation of the interrelationship among sub-sector is considered strength to these models. Still, there are some critiques regarding the use of partial equilibrium models for a single product or group of closely related agricultural commodities without linkages to other production lines in agriculture. The reason behind this is because, when speaking about agriculture, the demarcation of certain sub-sectors is not enough because used agricultural area of different crops is dependent of the profitability of all other crops, and because resource allocation between the sectors is not taken into account (Lehtonen, 2001).

Concerning the linkages with the rest of the economy, sectoral models often ignore them in much detail or they are integrated through variables forecasted as well. The value of the forecasted variables comes from their accuracy. Thus, the future projections or assumptions they are based on are important for making a good model. Price projections, GDP growth, population size are few of the externalities in the model as linkages with the rest of the economy.

As a small country opened to the world market, domestic prices are sensitive to the external/international price development. Therefore, domestic prices are modeled as a function of the key market prices (determined within AGMEMOD partnership), thus directly linked to the price projections made for them. This national model does not have a capacity to make projections of external prices (world prices or the prices of the major suppliers to the world market). These price projections are product of the combined AGMEMOD model for EU 27 Member states (Chantreuil et al. 2012).

The gross domestic product (GDP) per capita is used as an indicator of the standard of living of the population, as an element in the function of consumption. The future growth is based on official projections by the corresponding ministry, later extrapolated with a fixed rate.

The projection of population growth is important for making demand projections. So far, the population in Macedonia shows a trend of steady growth 0.32% per

year, but following the Malthus's principle of population about the periodic increase and decrease of population, it is not expected this trend to continue at the same pace. On the other hand, the UN projection on Macedonian population is a slow, almost stagnant growth in the next 40 years at an average annual rate of 0.13% (United Nations, 2004: 206). Therefore, since the model makes projections for the next ten years only, the current growth is buffered to 0.22%, taking something greater rate than projected by the UN.

As a final point, for easier comparison of the results with other AGMEMOD or similar models the model is built in euro currency, assuming the fixed exchange rate to the euro to remain in the future period.

6. Assumptions as limitations

The assumptions are made in order to complement missing segments, to ease the analysis or to rule out other factors that could make a change. Although assumptions are usually made to fixate some factors and expert opinion is often behind the estimations, still one can pose several questions suspecting the future.

Regarding the factors affecting the market supply and demand, the model assumes no significant changes in climate, neither in the number of market participants, or any other major structural change that would affect the agricultural markets. Can one predict the force of nature or the long-term effects it causes? For example, the model does not take into account the droughts and floods in the recent years. The combined AGMEMOD model takes into account the world food price crisis. The resulting key prices are used in the Macedonian model as well. But, what Macedonian model doesn't take into account is the real effect it had on the Macedonian economy. In addition, with such an extensive globalization, can one put a border and distinguish domestic producers as major local market players?

The assumptions on market price convergence are based on experience from the previous enlargements in 2004 and 2007, indicating that the adjustment of domestic prices of agricultural products at lower or higher prices in the EU occurred in the first few years after EU accession. Due to the fact that CAP is subject to considerable changes, or in other words it is 'a moving target', the assumed levels and measures of support in the EU accession scenarios are based on the expert knowledge and expected conclusion on the continuous and ongoing reforms of CAP.

Expert opinion is often used to resolve problems in the presence of uncertainty. In policy analysis, the uncertainties from the future or gaps in the current data are often filled in with an expert opinion. Thus it is a valuable input in the research or decision making process. And the accuracy of scientific viewpoint has an impact at the final model results.

In practice it is difficult to gather a number of expertises large enough to bring an objective assessment. Thus, the results of comprehensive policy analysis based on combined expert opinion are often subjective, producing different answers by different analysts (Keith, 1996). Keith also distinguishes three choices as appropriate analytical tools in combining expert opinion: consensus building methods, the best available method or punt. But, when working with a smaller group of experts, the scientific views should be weighted by the individual analyst.

7. Applicability

The paper so far described certain issues that raise the question why a partial equilibrium model is chosen as a method for assessing the development of the Macedonian livestock-feed sector. To answer this, a brief description of the AGMEMOD partnership is required. The AGMEMOD Partnership comprises universities, research institutes and government agencies from EU Member States, EU Candidate Countries (Macedonia, Croatia and Turkey) and other European countries (Russia, Ukraine, and Kazakhstan). The AGMEMOD model is a product of a joint collaboration, combining the modelling capacities of researchers with the agricultural sector knowledge of in-country experts, keeping focus on economic and policy plausibility (Chantreuil, et al, (2012). Despite all constraints coming out of the data quality and data availability, the possibility to have a model comparable with models for such a large number of countries, is a challenge both for the researchers and policy makers.

As mentioned previously, all partial equilibrium models on Macedonian agriculture are academic documents, master thesis and doctoral dissertation. As academics the motivation behind is own curiosity and the need to contribute to the social community by explaining observed phenomena. On the other side, according to the scenarios analyzed within models, they could be a practical tool for policy analysis of the governmental bodies supporting policy decision making.

The Macedonian model of livestock-feed sector proved to be a useful tool for understanding the effects of the application of different agricultural policy measures. On the other side, in the existing version it is less appropriate for market forecasting, in terms to anticipate market opportunities and threats for the commercial users (farmers, agribusiness companies, consumer organizations).

Table 3: Basic reasons for modelling

For whom?	Why?	What is expected?	Reasons behind communication gap	How to improve the relationship?
Us (act of curiosity)	Improving economic theory, explaining observed phenomena			Clear and professional approach in presenting results
Social community				
Commercial user	Building projections, simulation and 'what if' analysis	Ensuring commercial advantage	Price, impatience and lack of trust in results	Availability of quality data needed to build a good model
Governmental bodies		Data on market structure and performance and public expenditures on agricultural policy		

Source: Adjusted from Buckwell (1989).

Generally speaking, ensuring the usefulness of the model projections is a continuing problem among agricultural economists. Buckwell (1989) distinguish four groups of beneficiaries of the models, and also suggest reasons behind the communication gap between the modelers and the users (Table 1). The lack of trust in model result is one of them; and consequently motivating other institutions for providing quality input data for the model are given as a means to improve this relationship.

8. Conclusions

Agricultural sector modelling has become useful approach for market outlooks and policy impact assessments. Partial equilibrium models are often used to model agriculture sector, but practitioners find many pros and cons of using them as a method. The Macedonian experience confirms some typical obstacles and at the same time faces some new ones with a local perspective from the case of one transitional country.

Problems in data enquiry often appear to be a limiting factor. First, this is due to quite demanding database required by the model. In addition, the process of transition and consequently institutional reforms forced changes in the statistical

methodology of data collection, hence problems in data availability. The availability and quality of data subsequently affects the parameter estimation and model validation process.

Expert opinion and assumptions are used to complement missing segments and to define the ceteris paribus factors. The attempts to lower the level of subjectivity in building assumptions are often difficult, especially when a smaller group of experts are consulted and when their scientific views are weighted by the individual analyst.

The quality of assumptions explaining the operational environment in agriculture is factor affecting the usefulness of the model results. Furthermore, the success of representing linkages with other agricultural sectors and the rest of the economy to a large extend influence the model and it depends on the quality of assumptions they are supported with as well.

Despite all constraints coming out of the data quality and data availability, the possibility to have a model comparable with other AGMEMOD models, is a challenge both for the researchers and policy makers. With so many doubts on data quality in Macedonian case, the existing version should be used with precautionary for market forecasting.

The model proved to be suitable for policy simulations. By understanding the effects of the application of agricultural policy measure, it can assist the policy analysis of the governmental bodies, thus supporting policy decision making. Nevertheless, none of the existing partial equilibrium models on Macedonian livestock–feed sector found practical use so far. Besides motivating institutions for providing quality input data, the model builders should reveal the reasons behind the communications gap and try to improve the relationship with the local users.

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