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ASSESSING THE SERBIA EU INTEGRATION PROCESS IMPACTS ON KEY AGRICULTURAL MARKET PRODUCTS USING THE AGMEMOD MODEL

Abstract: The EU integration process brings substantial transformations across all economic domains, agriculture included, as a result of shifts in both the economic and political landscapes. These processes necessitate numerous adjustments to legislation, agricultural support structures, business conditions within the single market, and the harmonization of domestic producer prices with those prevailing in the EU market. The impacts of these changes can be assessed utilizing partial equilibrium models such as the AGMEMOD model. While this paper primarily lays the methodological framework for constructing the Serbian national AGMEMOD model, upon its completion, it could serve as a valuable instrument for evaluating the effects of political changes on agricultural markets in Serbia, aligning with the evidence-based policy principle, similar to other EU member states

Keywords: AGMEMOD model, modelling approach, agricultural markets, Serbia

1. INTRODUCTION

The European Union (EU) officially recognized the European perspective for all Western Balkan countries in June 2003, with Serbia applying for EU membership in December 2009, granted candidate status by the European Council in March 2012, and initiating accession negotiations in June 2013. From the agricultural sector standpoint, this implies that the Common Agricultural Policy (CAP) serves as the model for shaping Serbia's forthcoming agricultural policies (Erjavec et al., 2021). Institutional reforms are necessary to harmonize the legal and administrative structures of candidate countries with those of the EU in order to integrate the agricultural sector into the EU single market. After accession, candidate countries are required to demonstrate proficiency in managing the CAP policy cycle, which encompasses planning, distributing support payments, monitoring, evaluating, and participating in the development of the CAP support system.

The use of economic models to evaluate the effects of a new member state's accession to the EU on its agricultural sector and overall economy is a well-established practice endorsed by both the European Commission and the scientific community (Gohin and Zhang, 2020). Common tools used in such studies include Computable General Equilibrium (CGE) models, Partial Equilibrium (PE) models, and Farm management-type models (Žgajnar et al., 2021) available through the European Commission's IMAP platform (Bartova and M'Barek, 2008; Erjavec et al., 2011; Boulanger and Philippidis, 2015; Boysen et al., 2016; Niemi and Kettunen, 2018; Kranjac et al., 2020). This platform aims to provide robust scientific evidence supporting the implementation, monitoring, and evaluation of the CAP (M'barek and Delincé, 2015).

The AGMEMOD (Agricultural Member State Modelling) is a dynamic, econometric, multi-product, and multi-country PE model, frequently used for generating medium-term simulations of agricultural market outlooks and assessments of policy impacts for both EU member states, candidate countries, and other countries (Salamon et al., 2019). Additionally, alongside CAPRI and AGLINK, AGMEMOD stands as one of the three principal PE models within the IMAP platform. Using the AGMEMOD model, successful research and studies have been conducted thus far on the impact of a particular country's accession to the EU on its agricultural sector, exploring how changes in the political and economic environment affect key agricultural product markets (Kranjac et al., 2020; Kotevska et al., 2013; Van Leeuwen et al., 2011; Gavrilescu et al., 2006; Erjavec et al., 2006).
The objective of this paper is to initiate research on the impact of Serbia's accession to the EU on its key agricultural product markets using the AGMEMOD model. The paper will present the AGMEMOD methodology, assumptions, and the potential development of an AGMEMOD country template for Serbia, which is intended to serve as a baseline scenario for comparing the effects of changes on key agricultural product markets in the future. Additionally, the limitations of this type of research using partial equilibrium models will be discussed.

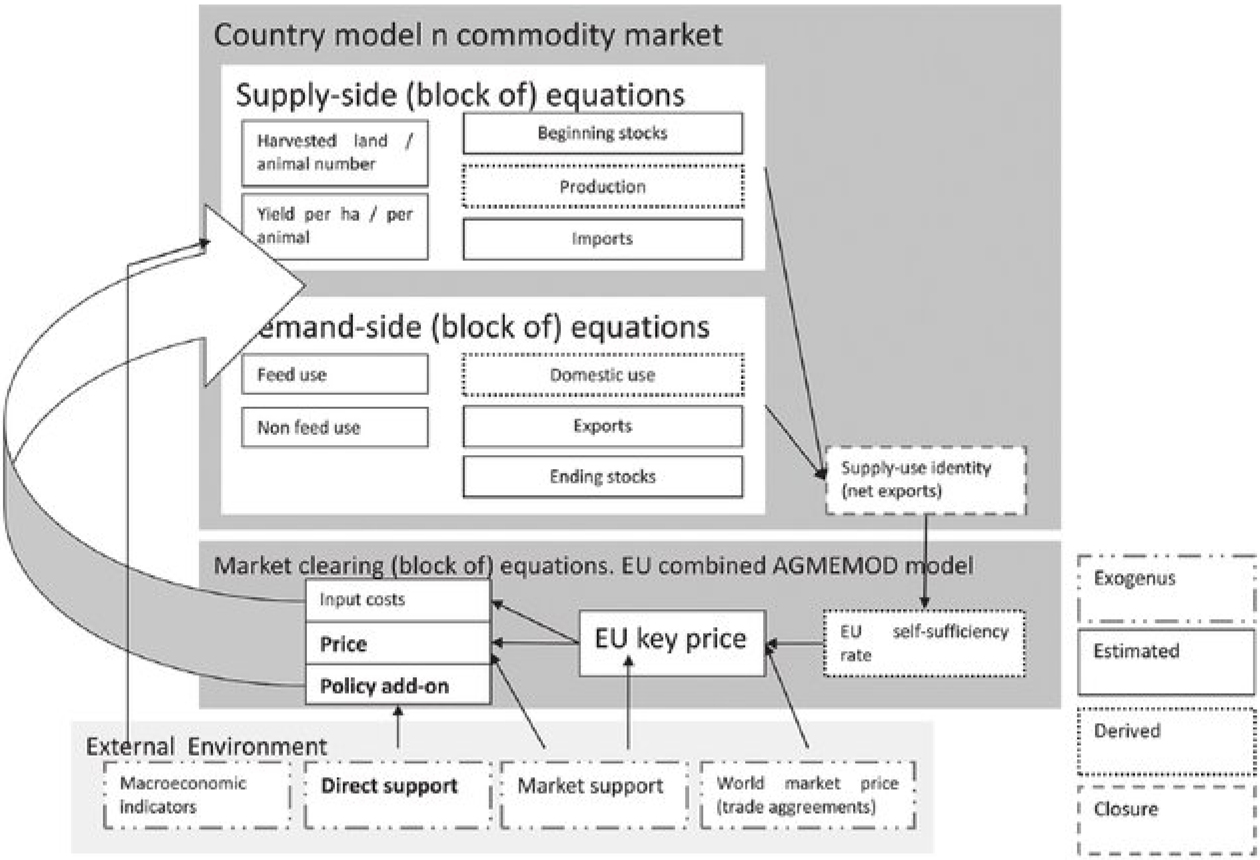
2. AGMEMOD PE MODEL

Partial equilibrium models are extensive market models that delineate particular sub-sectors or clusters of agricultural sub-sectors, delving deeply into the intricacies of supply and demand dynamics, price establishment, the interplay of agricultural inputs and outputs across various product lines, the effects of policies on supply, and producers' income, among other factors. These models are grounded in the neo-classical approach, wherein supply and demand reach equilibrium as producers and consumers strive to maximize profits and product utility.
AGMEMOD utilizes a series of commodity-specific model templates which make a country-specific models which are constructed to capture the intricacies of agriculture at the Member State or Country candidate level while enabling their integration into an EU-wide model (Salamon et. al., 2017). Maintaining strict adherence to these templates ensures analytical coherence among the country models, thereby facilitating aggregation towards an EU-level analysis. This adherence to model templates and a unified modelling approach also streamlines the comparison of policy impacts across diverse Member States. The primary purpose of the AGMEMOD model is to create mid-term simulations of key agricultural product markets (Outlooks) and to conduct scenario analyses to assess the impact of future changes in the political environment on these observed key agricultural markets (Kranjac, 2020). Mid-term outlooks of key agricultural product markets and scenario analyses can serve as the basis for evidence-based policymaking (Colen et al., 2016).
In order for the model to satisfy the condition of partial equilibrium, it is necessary to establish market equilibrium at each individual key market, which implies equality at a certain price level for the product. Which can be shown by the following general equation:

$$Production_t + Import_t + Beginning\ stocks_t = Consumption_t + Export_t + Ending\ stocks_t \quad (1)$$

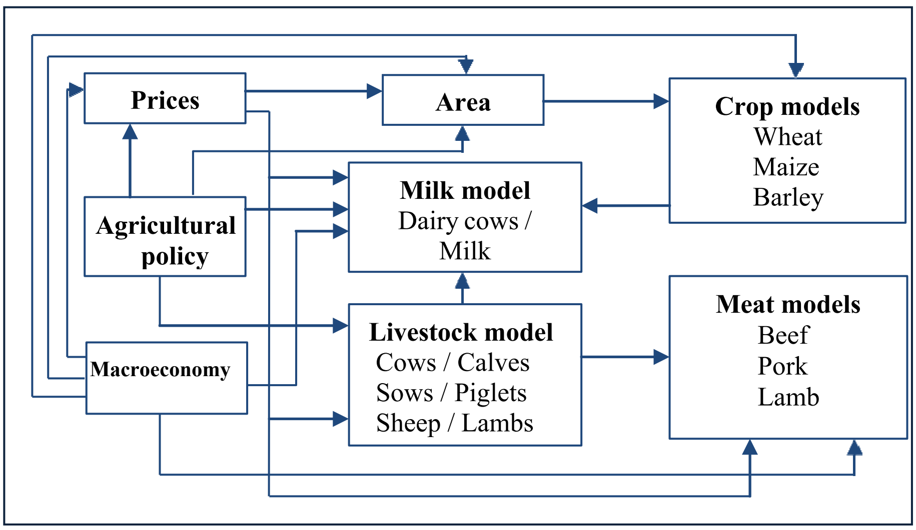
2.1. Data, structure and modelling approach within the AGMEMOD model

AGMEMOD is also a composite model whose modeling approach (bottom-up) is based on combining sub-models of key agricultural product markets into a template of a national model. The national template of the AGMEMOD model is constructed according to the EU Gold model template (Hanrahan, 2001). Subsequently, the national models of member states are combined into a single EU 28 model (Chantreuil et al., 2012).
The fundamental data for the key agricultural product markets consist of production-consumption balances for all observed key markets, including annual data on initial stocks, production, imports, human and animal food consumption, industrial consumption, exports, ending stocks, and domestic prices. The source for these data is relevant national databases such as the National Statistical Offices and the FAO or EUROSTAT database. These data represent endogenous data contained within the model. In addition to endogenous data, the model includes exogenous data such as macroeconomic and political variables and data on world market prices of key agricultural products. Macroeconomic variables contain data on inflation rates, per capita income, population, exchange rates, etc. Political variables encompass sets of data on regional and historical payments, coupled supports, production-related subsidies, state aids, etc.
Supply and demand, international trade, and domestic prices are endogenously determined within each sub-model, while changes in exogenous variables (macroeconomic variables, political instruments) cause changes in the behavior of producers and consumers within the key agricultural product market (Chantreuil et al., 2012). Using sets of econometrically estimated equations, the model generates projections of endogenous variables from exogenous and endogenous model data. Thus, the national AGMEMOD model dynamically represents changes in the behavior of stakeholders (producers and consumers) in response to exogenous changes within key agricultural product markets (Picture 1).



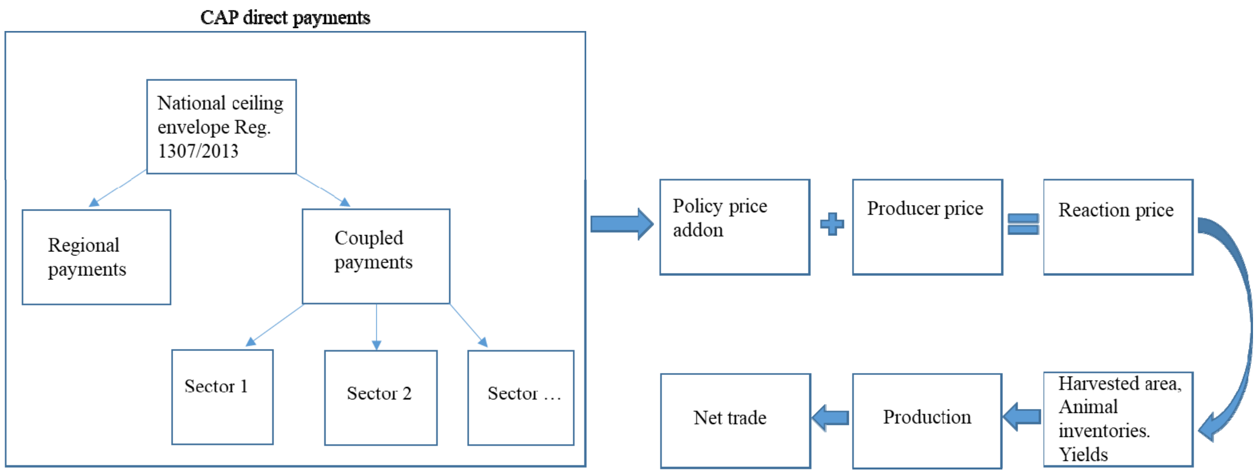
Picture 1. AGMEMOD country model template
Source: According to Chantreuil et al., 2012

Key agricultural market products are modeled in the interdependence of crop and livestock production, reflecting competition among substitution products through elasticity and different interactions between crop and livestock markets (Picture 2). The crop models are interconnected by allocating the total arable land utilized for crops and their prices, as they serve as inputs in livestock production. Additionally, crop models are interconnected by utilizing grains as feed in livestock models. Conversely, the quantity of livestock production determines the demand for grains for animal nutrition. The connection between meat models is established based on their relative prices, assuming they act as partial substitutes. The milk model is associated with the beef model through the total number of cows.



Picture 2. AGMEMOD sub-model interactions
Source: According to Kotevska et al., 2013

Political instruments in the model are represented through a policy harmonized approach, which involves incorporating current measures and instruments of the recent CAP reforms, delineating various direct payments, regional, historical and coupled payments, as well as distinct national policies prior to accession and the topping-up rates in the new member states (Salputra et al., 2011). Regional, production-related payments, as well as state aids, are recalculated and included as an addition to producer prices for each observed agricultural product market, in order to form a reaction price that influences production levels, cultivated areas, average slaughter weights, and numerous other variables in the national AGMEMOD model (Picture 3). Rural development measure funds are not included in the model, as models of this type are unable to incorporate second pillar supports of agricultural policy.



Picture 3. Policy-harmonised approach within the AGMEMOD model
Source: According to Kranjac et al., 2021

The following shows the general form of the econometric equation, according to which the model establishes output variables or the regression function through which the regression coefficients of the model are calculated.

General layout of the model equation:

$$Y = f(X_1; X_2; X_3) \tag{2}$$

Where:
Y = dependent indicator, which in specific equations can be, for example, yield, production, area, etc.
$X_1; X_2; X_3$ = variables that represent independent factors that have an impact on the change of the dependent indicator

It can also be written as:

$$Y = \alpha + \varepsilon\beta_1 X_1 + \varepsilon\beta_2 X_2 + \varepsilon\beta_3 X_3 \dots + \epsilon \tag{3}$$

Where:
Y = dependent indicator
α = intercept
ε = coefficient of elasticity
β = regression coefficient
X_{123} = independent factors that have an influence on the change of the dependent indicator
ϵ = error term

3. SERBIAN NATIONAL AGMEMOD TEMPLATE

In order to assess potential impacts of Serbia's accession to the EU on its key agricultural product markets it is necessary first to develop Serbian national template in AGMEMOD model.
The process of developing the Serbian AGMEMOD national model includes:

- Input data entry (endogenous and exogenous) into the model
- Setting up and estimating econometric behavioral equations
- Model calibration
- Model evaluation through statistical tests and expert assessments

Following the input of input data, econometric behavioral equations are set up for all major indicators (production, imports, exports, yields, etc.) within the key agricultural product markets of the Serbian national AGMEMOD model. Depending on the set of equations, it is necessary to define a set that reflects supply (initial stocks, production, and imports) and demand (domestic consumption, exports, and closing stocks) in the key market. Both sets of econometric equations determine how market equilibrium is achieved in a given year at a specific price for each product. Econometric behavioral equations are estimated according to the appropriate econometric methodology specified by the general rules of the AGMEMOD modeling approach (Hanrahan, 2001).

After estimating the econometric equations, the Serbian model is to be calibrated to achieve a better representation of the real situation in key agricultural markets. The calibration process involves re-estimating econometric behavioral equations to align regression coefficients in equations so that projected variables are consistent with economic theory, biological constraints, and standard statistical tests. Generally, calibration techniques are used for shorter time series of input data (balance data), as is the case in constructing the Croatian model (Kranjac et al., 2020). In addition to shorter input data series, calibration is performed due to structural declines in production caused by policy changes and economic crises, as well as occasional poor-quality balance data from the State Bureaus of Statistics.

Model evaluation in terms of testing the significance of regression parameters is conducted through the T-test, followed by testing the significance of the entire regression through the F-test with the coefficient of determination R^2. Estimated results are then evaluated with standard statistical tests for heteroscedasticity (White heteroscedasticity) and autocorrelation (Durbin-Watson test) (Bartova and M'barek, 2008).

In addition to statistical model evaluation, the Serbian model has to be evaluated by experts in two steps. In the first step, an international expert in key agricultural markets (agricultural economist) verifies the consistency of the estimated econometric equations. Then, at least two domestic experts specialized in domestic agricultural product markets, one specializing in crop markets and the other in livestock markets, have to assess the initial baseline simulation of the model with feedback on the projections made. Based on the experts' comments on individual projections of key agricultural product market variables, additional calibration of regression coefficients in equations will be carried out. For the complete development of the Serbian AGMEMOD template, it is necessary to separately develop crop and livestock sub-models and then incorporate them into the Serbian national AGMEMOD model of partial equilibrium of key agricultural product markets. Once the Serbia national AGMEMOD model template is developed according to the AGMEMOD modeling approach, then it can be integrated into the common EU AGMEMOD model.

3.1. Approach to the modelling of the Serbian crop model within AGMEMOD

The first step in developing the crop model involves modeling the total areas occupied by cereals, oilseeds, and tuber and root crops. The shares of total areas are allocated to individual groups (cereals, oilseeds, tuber and root crops), and the projected redistribution of land among crop groups depends on the expected gross return rate, while the allocation of land for the production of each product depends on the relative real gross return rate, including direct payments.

Therefore, the equation for the total harvested area of cereals, oilseeds, tuberous and root crops can be written as:

$$ah_{i,t} = f\left(p^{j}_{l,t-1}, ah_{i,t-1}, V\right) \qquad j = 1,\ldots,n; \;\; i,l = 1,\ldots,3; \;\; i \neq l \tag{4}$$

Where:

$ah_{i,t}$ = harvested area in year *t* of crop group *i*

$p^{j}_{i,t-1}$ = real price of crop *j* belonging to crop group *i* in year *t-1*

V = vector of exogenous variables that can affect the harvested crop area *i* (e.g. certain policy instruments such as coupled payments).

The share of crop *k* belonging to the crop group is determined according to the equation:

$$sh^{k}_{i,t} = f(p^{j}_{i,t-1}, sh^{k}_{i,t-1}) \qquad j,k = 1,\ldots,n \tag{5}$$

The share of the harvested area of a particular crop is calculated according to the principle 1 - part of the areas of all other *(n-1)* crops, which means that the harvested area of the crop = total harvested area * share of the *n* crop.

The yield of crop *k* which is in the crop group *i* is expressed as:

$$r^{k}_{i,t} = f(p^{j}_{i,t-1}, r^{k}_{i,t-1}, V) \qquad j,k = 1,\ldots,n \tag{6}$$

Where:

$r^{k}_{i,t}$ = yield per hectare of crop *k* which is in the crop group *i*

$p^{j}_{i,t-1}$ = real price of crop *j* belonging to crop group *i* in year *t-1*

$r_{i,t-1}^{k}$ = yield per hectare of crop *k* which is in crop group *i* in year *t-1*
V = vector of exogenous variables that can affect the yield per hectare of crop *k* located in crop group *i*.

Based on the previous equations, the production of each crop is determined: crop production = harvested crop area * crop yield.

The following set of equations shows how consumption is modelled in the crop model. Consumption in the crop model includes three segments: processing, animal feed and human consumption (per capita), and is modelled according to the following equations:

$$FU_{i,t}^{k} = f(p_{i,t}^{j}, Z) \qquad j,k = 1,\dots,n \tag{7}$$

Where:
$FU_{i,t}^{k}$ = consumption of crop *k* belonging to crop group *i* for fodder
$p_{i,t}^{j}$ = real price of crop *j* belonging to crop group *i* in year *t*
Z = vector of endogenous variables that can influence feed consumption (e.g. meat production).

$$NFU_{i,t}^{k} = f\left(p_{i,t}^{j}, NFU_{i,t-1}^{k}, V\right) \qquad j,k = 1,\dots,n \tag{8}$$

Where:
$NFU_{i,t}^{k}$ = Consumption of crop *k* belonging to the crop group *i* for human consumption
$p_{i,t}^{j}$ = real price of crop *j* belonging to crop group *i* in year *t*
$NFU_{i,t-1}^{k}$ = Consumption of crop *k* belonging to crop group *i* for human consumption in year *t-1*
V = vector of exogenous variables that can affect human consumption (e.g. total population).

$$Cr_{i,t}^{k} = f\left(p_{i,t-1}^{h}, p_{i,t-1}^{l}, Cr_{i,t-1}^{h}, VZ\right) \qquad h,k,l = 1,\dots,n \tag{9}$$

Where:
$Cr_{i,t}^{k}$ = processing of oilseeds of crop *k* belonging to the crop group *i* for the production of oil and oil cakes in the year *t*
$p_{i,t-1}^{h}$ = the actual price of the oil of crop *h* belonging to the crop group *i* in the year *t-1*
$p_{i,t-1}^{l}$ = the real price of the oil cake of crop *l* belonging to the crop group *i* in the year *t-1*
$Cr_{i,t-1}^{h}$ = processing of oilseeds of crop *h* belonging to the crop group *i* for the production of oil and oil cakes in the year *t-1*
VZ = vectors of endogenous and exogenous variables that can affect the amount of processing (e.g. imports, oil extraction).

The equations of stocks, imports and exports in the farming and livestock models have the same following form, and are expressed as follows:

$$St_{i,t}^{k} = f\left(Pr_{i,t}^{k}, Du_{i,t}^{k}, St_{i,t-1}^{k}\right) \tag{10}$$

$$Ex_{i,t}^{k} = f\left(Pr_{i,t}^{k}, Du_{i,t}^{k}, Ex_{i,t-1}^{k}\right) \tag{11}$$

$$Im_{i,t}^{k} = f\left(Pr_{i,t}^{k}, Du_{i,t}^{k}, Im_{i,t-1}^{k}\right) \tag{12}$$

Where:
$St_{i,t}^{k}, Ex_{i,t}^{k}, Im_{i,t}^{k}$ = stocks, export and import of crop k belonging to crop group *i* in year *t*
$Pr_{i,t}^{k}$ = total domestic production of crop *k* belonging to crop group *i* in year *t*
$Du_{i,t}^{k}$ = total domestic consumption of crop *k* belonging to crop group *i* in year *t*
$St_{i,t-1}^{k}, Ex_{i,t-1}^{k}, Im_{i,t-1}^{k}$ = stocks, export and import of crop *k* belonging to crop group *i* in year *t-1*.

3.2. Approach to the modelling of the Serbian livestock model within AGMEMOD

Similarly, to the crop model, the general form of equations in the livestock model illustrates the way in which supply and demand are modeled. The first set of equations represents the way in which supply is modeled.

The number of breeding animals (breeding herd) is modelled by the following equation:

$$cct_{i,t} = f\left(cct_{i,t-1}^{k}, p_{i,t}, V\right) \qquad k = 1, \dots, n \quad i = 1, \dots, n \qquad (13)$$

Where:

$cct_{i,t}$ = number of breeding animals *i* in year *t*

$cct_{i,t-1}^{k}$ = ending stocks of breeding animals *i* within type of breeding animal *k* in year *t-1*

$p_{i,t}$ = the real price of a breeding animal *i* in year *t*

V = vector of exogenous variables that can affect the final stocks of breeding animals *i*

The number of animals produced from the breeding herd can be expressed as follows:

$$spr_{i,t} = f\left(cct_{i,t-1}, ypa_{i,t}\right) \qquad i = 1, \dots, n \qquad (14)$$

Where:

$spr_{i,t}$ = number of animals *i* produced from breeding herd in year *t*

$cct_{i,t-1}^{k}$ = final stocks of breeding animals *i* within type of breeding animal *k* in year *t-1*

$ypa_{i,t}$ = yield per animal from the breeding herd in year *t*

Within each animal species *i* there may be *m* categories of slaughtering *j*. The number of animal species *i* slaughtered in slaughtering category *j* can be expressed as:

$$ktt_{i,t}^{j} = f\left(cct_{i,t}^{j}, p_{i,t}, z_{i,t}^{j}, V\right) \qquad i = 1, \dots, n \quad j = 1, \dots, m \qquad (15)$$

Where:

$ktt_{i,t}^{j}$ = the number of slaughtered animals in the category *j* animal species *i* in the year *t*

$cct_{i,t}^{j}$ = ending stocks of animal species *i* within species of slaughtered animals in category *j* in year *t*$p_{i,t}$ = real price of animal species *i* in year *t*

$z_{i,t}^{j}$ = endogenous variable representing the proportion of different categories of slaughtered animals for the respective animal species

V = vector of exogenous variables that can affect the number of slaughtered animals

Average slaughter weight in animal species *i* can be expressed as:

$$slw_{i,t} = f\left(slw_{i,t-1}, p_{i,t}, z_{i,t}^{j}, V\right) \qquad i = 1, \dots, n \quad j = 1, \dots, m \qquad (16)$$

The total production of meat from an animal species *i* is calculated as the result of the average slaughter weight multiplied by the total slaughtering within the same species of slaughtered animals, and can be expressed as:

$$ktt_{i,t} = \sum_{j} ktt_{i,t}^{j} \qquad i = 1, \dots, n \quad j = 1, \dots, m \qquad (17)$$

The total domestic consumption of a certain type of meat is calculated by the consumption of meat per capita multiplied by the total number of the population. Consumption of a certain type of meat per capita is calculated as:

$$upc_{i,t} = f\left(upc_{i,t}, p_{i,t}, p_{k,t}, gdpc_{t}, V\right) \qquad k, i = 1, \dots, n; \quad k \neq i \qquad (18)$$

Where:

$upc_{i,t}$ = meat consumption per capita of animal species *i* in year *t*

$p_{i,t}$, $p_{k,t}$ = real price of animal species *i*,*k* in year *t*

$gdpc_{t}$ = real income per capita in year *t*

V = vector of exogenous variables that can influence meat consumption per capita

3.3. Scenario development

In order to measure effects of protentional impacts of the integration processes on Serbian key agricultural market products, several scenarios within AGMEMOD model could be developed similar to scenarios presented in Kotevska et al. (2013):

1) *Baseline scenario* - It embodies the scenario of 'no policy change,' serving as a counterfactual to discern the impacts on Serbian agricultural markets and to provide a benchmark against which policy change simulations

can be assessed. It assumes no accession to the EU and no alteration in policy measures, yet incorporates an augmentation of the budget allocated for agricultural support in line with the plans and projections outlined by the Serbian Ministry of Agriculture.

2) *Price convergence scenario* - envisions EU accession until the end of decade and the adjustment of prices for covered commodities to align with the integration into the common European market.
3) *EU-optimistic scenario* - anticipates EU accession until the end of decade, along with price adjustments and the implementation of CAP rules under optimistic assumptions regarding budget allocations and permissible measures. These include a national ceiling in line with Serbian Ministry of Agriculture, a topping-up rate from the national budget similar to Croatia's case in 2013, levels of direct payments for arable land, and perennial crops, coupled payments for beef and lamb, and the absence of historical payments.
4) *EU-pessimistic scenario* - anticipates EU accession until the end of decade, alongside price adjustments and the implementation of CAP with a constrained budget and limited policy measures. This includes a national ceiling set at 75%, a fixed topping-up rate from the national budget at 30% and the absence of coupled and historical payments.

4. CONCLUSION

Modelling the agricultural sector has emerged as a beneficial method for forecasting market trends and evaluating policy impacts. While partial equilibrium models are frequently employed in agricultural sector modelling, practitioners encounter various advantages and disadvantages associated with their utilization.

Challenges in data acquisition frequently emerge as a constraining factor. Primarily, this is attributed to the demanding nature of the database required by the model. Additionally, the transition process and subsequent institutional reforms have necessitated changes in the statistical methodology of data collection, leading to issues with data availability. The availability and reliability of data subsequently impact the process of parameter estimation and model validation.

Expert opinions and assumptions are utilized to supplement missing segments and establish ceteris paribus factors. However, efforts to minimize the level of subjectivity in forming assumptions are often challenging, particularly when consulting a limited number of experts whose scientific perspectives are weighed by individual analysts.

The quality of assumptions delineating the operational environment in agriculture significantly influences the utility of the model results. Moreover, the effectiveness of representing linkages with other agricultural sectors and the broader economy largely depends on the quality of the assumptions they are underpinned by.

Generally, caution should be exercised when interpreting the modelling results, as they cannot serve as the sole basis for decision-making by policymakers. Therefore, decision-making process should be complemented by an assessment of various economic models and other agricultural policy assessment methods.

One of the primary benefits of AGMEMOD as a partial equilibrium sectoral model lies in its capacity to apply a policy-harmonized approach, which allows for the connection or disconnection of specific policy instruments to or from individual agricultural commodities. This capability facilitates a quantitative examination of how policy modifications influence both the markets and the production composition within the examined agricultural sectors. Although this paper serves solely as a methodological background for development of the Serbian national AGMEMOD model, once fully developed, it could serve as a valuable tool for assessing the impacts of political changes on agricultural markets in Serbia like in other EU member states, following the evidence-based policy principle.

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