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**Mathematical Models of the Research Institute of Agricultural Economics
Applied to Czech Agriculture**

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AGRO-3 model

Model AGRO-3 is a nonlinear optimisation model of the Czech agrarian sector that is based on the principles of market equilibrium in three key markets of the agricultural sector: agricultural products (market 1), food-industry products (market 2), and food products for retail and human consumption (market 3). Exogenous variables of the model are represented by general macroeconomic conditions (such as world prices for agricultural commodities, inflation, the exchange rate of the national currency to \$US, income of the population, etc.) and the internal economic conditions of the Czech agriculture (including the costs of agricultural producers in market 1, functional relations between costs and market prices in markets 2 and 3, food consumption and economic behaviour of the population in the base year). Exogenous variables also include the provisions of the agricultural policy, including international commitments of the Czech Republic.

Endogenous variables are represented by the production amounts of all commodities, market prices in all markets and costs in markets 2 and 3 (nonlinear constraints of the model), further corresponding with the quantities of food consumption by the population relative to food-market prices and finally possible exports and imports in all markets. The optimisation criteria include the profit of agricultural producers, processors and retailers. The model enables researchers to solve various questions about the impact of agrarian policies on the development of the national agricultural sector. Model AGRO-3 is programmed in GAMS.

IDARA model

Simulation model IDARA (which was developed from the original model MFSS99 for EU member states) is a transparent modelling tool for evaluating macroeconomic scenarios

relating to the development of agriculture. Model IDARA is a supply-and-demand partial equilibrium (PE) model of agricultural raw materials. Its structure corresponds to the commodity conception of the Economic Accounts for Agriculture, i.e. on the one hand balance and use of agricultural commodities, including the processing of some commodities (such as dairy products and SMO or industrial potatoes/starch), and on the other hand the cost structure of agricultural commodities resulting from direct variable costs (intermediate consumption), over gross and net value-added, until the net income for commodities is determined. Supply and demand functions for agricultural commodities are derived econometrically on the basis of the available time series and elasticities of supply and demand. The IDARA model uses macroeconomics assumptions (world prices of agricultural commodities, development of GDP, inflation rate – exogenous variables) that influence the national market (domestic market prices, domestic production, exports and imports – endogenous variables). The final model indicator is the net export (the difference between export and import) for every commodity. The IDARA model is programmed in GAMS.

ZEM-1 model

The problem of evaluating the likeliest developments in agricultural policy and its impact on the Czech agriculture before and after EU accession – and especially the need to evaluate continuous changes in connection with the negotiations between the Czech Republic (CR) and the EU – led to the creation of the heuristic model ZEM-1. This model is not based on some standard mathematical method (as opposed to the AGRO-3 and IDARA models), but is derived from logically ordered sets of algorithms (heuristic model), which make it possible to compute the required final indicators from the input data given. The model is constructed with the most current basic data (an average of years 2000 and 2001) and produces values of indicators for the time series 2002–06, based on assumed data from other sources, expert predictions or calculation by other models (e.g. the AGRO-3 and IDARA models). The model supports scenarios of possible developments in the Czech agrarian sector, including variants such as profitability, the competitive advantage of agricultural commodities and regional modifications, depending on the different natural conditions of the CR. It also supports the input of data relating to agricultural production by region. Model ZEM-1 was created in an Excel environment.

EAA model

The Economic Accounts for Agriculture (EAA) in the Czech Republic have been worked out by the Research Institute of Agricultural Economics (RIAE) in Prague, from the year 1994 with the methodological assistance of ASA in Bonn. RIAE was the first research institute in the CR to translate the documents of Eurostat into Czech methodological work as the obliged manual for constructing EAA.

The basic principle of EAA is based on an approach where the agricultural branch is considered as *a single national farm*, without respect to the real farm structure. This so-called ‘functional approach’ defines the agricultural sector as a set of production branches. This methodical approach differs from the one used in other sectors of the national economy, where the so-called ‘institutional approach’ is commonly used. The latter approach defines the sector as a set of enterprises (institutions), whereby their main activities correspond to the overall sector. The tendency towards unifying national accounts among all the sectors of the national economy caused a change in the EU methodology (expressed in the new manual on the EAA/EAF 97, which has been obligatory for EU member states since 1998), based on a modified version of the institutional approach. According to this new approach, the agricultural sector is considered to be *a set of agricultural units*, which in principle include all enterprises (as types of activity units) that provide some agricultural activities and are reduced only to those agricultural activities and others with which those activities are inseparably linked.

The construction of EAA in the CR by RIAE for the years 1994–98 is based on the original functional approach (in accordance with the manual on the EAA/EAF, 1987). But in 1999, the Czech Statistical Office (CSU) additionally constructed the EAA for the first time (for the year 1998), based on the above-mentioned new methodology.

PEM model

The Policy Evaluation Matrix (PEM) is the methodological instrument created by the OECD for evaluating agricultural policy efficiency. The OECD PEM model was modified by researchers in the Czech Republic to account for conditions in the Czech agriculture.

The model enables a comparison of the impact of various kinds of market and budgetary support given to farmers. The starting point of the analysis of policy effects for the PEM is the producer-support estimate, which has eight main categories of support distinguished by implementation criteria (MPS and seven different kinds of budgetary payments).

In 2001–02, the research team solved the key problem connected with the implementation of the PEM crop-model of the Czech agriculture conditions (PEM-CR-3K for three commodities), which was mainly to do with difficulties of finding supply and demand elasticities. The results were presented in the framework of a project of the Grant Agency of the Czech Republic, “Using [the] off-PEM method for evaluating agricultural policies”.

Functional relations of the model were computed from the time series of 1995–2001, based on a real database of the Czech agriculture. Model simulations are realised for the period 2002–07, where 2002–03 is assumed as the period before the EU enlargement and 2004–07 as the period after the EU accession of the Czech Republic.

Model PEM enables a simulation of the influence of Czech agricultural policy before and after EU accession, on the production, consumption and effectiveness of the chosen commodities by the support measures of MPS, OUT, DPA and INP.

Model PEM-CR-3K was enlarged to include the entire Czech agricultural sector, in the form of the PEM-CR-9K model, which includes the nine main commodities (five commodities related to plant production and four related to animal production). Initially there was a problem with an insufficient time series for the elasticity estimate, for which two approaches to successfully solve the problem have been suggested and discussed.

AGMEMOD model

Model AGMEMOD is an econometric supply and demand model intended for simulating the development of the EU agricultural market. Every EU member state formulates its national module according to common methodological principles, which support time-series production and economic indicators for the main agricultural commodities. Exogenous variables of national models are EU market prices, while domestic market prices are the endogenous variable. The results of the model are calculations of net exports as a consequence of the model’s calculations of supply and demand for each commodity.

National models are connected in a composite model of the EU-15 (in 2003) and EU-25 (in 2004) for simulating market relations before and after EU enlargement. The AGMEMOD model for the Czech Republic was programmed in Excel.

FARMA-4 model

One significant research aim has been comparing the economic perspectives of Czech farmers with those of farmers in neighbouring EU states, with respect to agrarian policies for the CR

and the EU before and after the EU's accession of the CR (for the years 2000 and 2004). At the same time, it is important to take into account suggestions in the EU that the level of direct payments for 'old EC member countries' will be 100%, while 'new EU member countries' will only receive 25% with the possibility of national top-up to 55%.

For the realisation of these considerations, a linear optimisation model – FARMA-4 – was created. This model is able to model the intensity, market prices, supports and costs for agricultural commodities in the economic environment before and after EU enlargement for an optimal production structure of selected types of farms in the CR and presumptions of production structure among comparable EU countries. The optimisation model criterion is farm profit from agricultural activities. Research on the optimal structure of farms can consider issues such as

- full usage (not using all available farm land), and
- limits (or lack of limits) in the availability of labour.

The FARMA-4 model is programmed in GAMS.

SPOTREBA-POTRAVIN (FOOD CONSUMPTION – demand model)

General information about food consumption in the Czech Republic is issued by the CSU (Czech Statistical Office), towards the end of the previous year. Therefore a methodology of preliminary judgment (calculation) of food consumption was developed in first quarter of the following year.

The philosophy for judging general consumption is based on calculations of consumption for only basic food commodities (consumption of drinks is not estimated). Food consumption is calculated using the balance sheet method, with the following statistical information:

- gross agricultural production;
- production of selected products in the processing industry;
- state of initial and final stocks in the food processing industry;
- imports and exports of food products from customs statistics;
- self-sufficiency of food products; and
- family budget study.

Average annual food consumption per capita is calculated based on the total population in the CR, and includes all types of consumption (retail sales, consumption by processing industries, etc.).

PRICES model

Price predictions have already been provided by the RIAE on a regular basis for a long time. The methodology was developed in 1993–94, then was honed, checked and extended step by step. This model offers monthly predictions of producer prices in agriculture, prices for food producers and consumer prices in the CR. Every month there are predicted prices for selected commodities three-months ahead. The PRICES model is an econometric model based on standard mathematical and statistical methods.

POTR-3 model

Model POTR-3 is a heuristic modelling apparatus for analysing the economic structures in food processing industries, in conjunction with modelling algorithms for predicting the costs and market prices of industrial producers (CPV) for the main food commodities, in relation to the market prices of agricultural producers (CZV) and their extension to consumer prices (SC). With respect to the fact that model POTR-3 is based on an analogical production structure like model AGRO-3, model POTR-3 serves as a satellite model for AGRO-3, to verify the cost and price relationships for the processed commodities of the model AGRO-3. Model POTR-3 is programmed in Excel.

The BSL database

A significant and necessary part of described modelling apparatus of RIAE is creating a database that offers fast, operative, comprehensive, digestible and statistically correct data about agriculture and the agrarian sector (and other regional economies of the CR), which a modelling apparatus needs for model activity. Towards this goal, RIAE created a large model database – BASELINE (BSL) – which includes detailed information and possible unified structure data behind all the major agricultural commodities, along with choice macroeconomic indicators. BSL includes production and economic indicators for individual commodities in a time series for actual figures (1995–2002). For the selected indicators, the model can be used to make predictions (2003–06), which the RIAE especially uses for modelling predictions related the Czech Republic's accession to the EU.

Information sources for BSL are primarily the Czech Statistical Office, along with some statistics of the Czech ministry for agriculture and finally some special expert studies.

ABOUT ENARPRI

ENARPRI is a network of European agricultural and rural policy research institutes formed for the purpose of assessing the impact of regional, bilateral and multilateral trade agreements concluded by the European Union or currently under negotiation, including agreements under the WTO, EU accession, Everything But Arms (EBA), EuroMed and Mercosur. It also addresses the wider issues of the multifunctional model of European agriculture and sustainable development of rural areas. Participants in the project include leading national institutes and research teams from 13 countries (11 EU member states and 2 accession countries).

AIMS

- Creation of an institutional structure linking key research institutes with major benefits for improved exchange of information and policy analysis both in the short and long run,
- Development of improved tools for impact assessment,
- More effective impact assessment of trade agreements on a variety of important social, economic, and environmental indicators and an assessment of multi-functionality, and
- Clearer analysis of the need for EU policy adjustments.

PARTNER INSTITUTES

- **CEPS**, Centre for European Policy Studies (Belgium)
- **FAL**, Federal Agricultural Research Centre (Germany)
- **FOI**, Danish Research Institute of Food Economics (Denmark)
- **IEEP**, Institute for European Environmental Policies (UK)
- **INEA**, Istituto Nazionale di Economia Agraria (Italy)
- **INRA**, Institut National de la Recherche Agronomique (France)
- **IRWIR PAN**, Institute of Rural and Agricultural Development/Polish Academy of Sciences (Poland)
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