Development Economics and Public Policy

WORKING PAPER SERIES

Paper No. 11

General Equilibrium Modelling Applied to Romania (GEMAR): Focusing on the Agricultural and Food Sectors

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November 2003

ISBN: 1-904-143-68-7, 978-1-904-143-68-0

Further details: Institute for Development Policy and Management
Published by: University of Manchester,
Harold Hankins Building, Precinct Centre,
Oxford Road, Manchester M13 9QH, UK
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General Equilibrium Modelling Applied to Romania (GEMAR): Focusing on the Agricultural and Food Sectors[1]

Serban Scrieciu[2] and Adam Blake[3]

Abstract

Applied general equilibrium modelling represents a powerful tool for assessing future likely economic changes due to upcoming or hypothesised policy shocks such as those brought about by EU enlargement. It entails the main advantage of considering the complex simultaneous linkages, interactions and feedback effects between various sectors, institutions and factor resources within an economy, as well as the inter- and intra-industry trade links with other economies across the globe. This technical paper develops a general equilibrium model applied to Romania (GEMAR) with an emphasis on the agricultural and food processing activities. A simple simulation example is then given for illustrative purposes. More extensive use of GEMAR will be made in other forthcoming papers where the model will be employed to identify those economic impacts stemming from incorporating Romania's agricultural and food sectors into EU/CAP structures. The model is static with constant returns to scale and perfect competition in production. Other studies have deployed modelling techniques to deal with EU accession issues. However, the literature assessing separately the economic effects of CAP enlargement for Romania is extremely sparse. In addition, as far as the authors are aware of, there are no studies that solely focused on the likely economic effects of CAP enlargement on Romanian agricultural and food processing sectors at a disaggregated level and within a single-country general equilibrium framework. Hence, the paper should not only fill in a gap in the modelling literature dealing with EU's next phase of eastward expansion but also tackle an issue of current interest for both researchers and policy-makers involved in agriculture and economic development.

Keywords: Applied General Equilibrium Modelling, Romania, Agriculture

INTRODUCTION

Applied General Equilibrium (AGE)[4] models represent a relatively recent category of modelling methods that convert Walrasian general equilibrium models[5] from an abstract representation of an economy to a realistic representation of actual economies (Shoven and Whalley, 1984). Although the computer representation of the economy is complex enough to reflect its essential features it is yet simple enough to be tractable (Kehoe and Kehoe, 1994). An AGE model could be described as an integrated system of non-linear simultaneous equations derived from economic theory of optimising behaviour of all agents within an economy (i.e. consumers, producers, government, and, foreigners) that attempts to capture all the transactions taking place between the respective agents so that it renders an all-markets clearing equilibrium numerical solution. In other words, it aims to mathematically describe the simultaneous linkages and interactions between various sectors, institutions, and factor resources of an economy (Vargas et al., web-book). Hence, AGE modelling represents a powerful tool for predicting possible economic outcomes that might be triggered by given policy shocks. For this reason it could be compared to a scientific laboratory experiment where the modelled economy constitutes the subject of the experiment, the assumptions made are the necessary conditions for the experiment to work, and the exogenous policy changes are the shocks that are administered to the subject in order to seek their potential effect.

AGE techniques have been increasingly employed in the literature dealing with issues of EU eastward enlargement and its impact on agricultural activities in transition economies (Liapis and Tsigas, 1998; Jensen et al., 1998; Acar, 1999; Herok and Lotze, 2000; Kuhn and Wehrheim, 2002; Frandsen et al., 2002; Jensen and Frandsen, 2003). This is because general equilibrium modelling seems to be not only the most suitable methodology for predicting likely effects of regional enlargement but also a useful analytical device for separating the expected policy changes of interest from other numerous factors that may be at work with EU integration (FAO, 2003). In addition, general equilibrium modelling addresses the workings of an economy in an integrated manner. Thus, relative to partial equilibrium modelling it displays the main advantage of considering the complex inter-linkages between all the sectors and economic agents of an economy, mainly through factor markets and intermediate input use. Most studies that employ AGE techniques to investigate EU enlargement and CAP integration issues treat the CEECs as a single entity without evaluating the effects for particular countries within the respective region (Jensen et al., 1998; Herok and Lotze, 2000). Other studies do single out the economic impacts across CEE countries (Fuller et al., 2002; Jensen and Frandsen, 2003). However, they focus only on the first-wave accession countries that have recently joined the EU.

Studies that separately consider general equilibrium effects of CAP enlargement on agriculture for Romania (and Bulgaria) are extremely sparse.[6] These mainly consist of Brockmeier et al. (2003) and Banse (2003) that take account of accession effects within a multi-country modelling framework that include Romania and Bulgaria amongst the rest of CEECs. Brockmeier et al. (2003) is however limited in providing a representative picture of the accession impacts on agriculture in Romania. This is because it makes two main assumptions under which the CAP will be extended to Romania and Bulgaria. First, direct payments are extended to the two countries based on figures for all other candidate countries, and second, the quotas are fixed at the (then) current production level. In other words, because the study was undertaken (in 2003) before agricultural negotiations in Romania and Bulgaria were actually concluded (in 2004), the authors' estimated impacts may be to some extent misrepresented through the assumptions made with reference to two countries. For example, Brockmeier et al. (2003) find that the Romanian post-accession production of raw milk does not change and that of sugar and diaries significantly declines. However, Romania has obtained production quotas for milk and sugar that seem to not be binding with EU accession and consequently, growth in these areas is expected to occur.[7] Banse (2003) provides a more complex analytical approach by combining applied general equilibrium models with partial equilibrium models. Yet again the author's analysis is undertaken before negotiations on agriculture between EU and Romania were concluded and consequently merely extends the negotiation outcomes from the first-wave of accession countries to second-wave candidate countries. In addition, as far as the authors are aware of, there are no studies that solely focused on the likely economic effects of CAP enlargement on Romanian agricultural and food processing sectors at a disaggregated level and within a single-country general equilibrium framework.[8] A similar analytical approach (i.e. single-country AGE model) is undertaken in Bayar et al. (2004). Nonetheless, the study incompletely addresses the economic impacts on agriculture of Romania's accession to the EU. This is explained by the fact that although the authors do develop a single-country applied general equilibrium for Romania, they employ it to evaluate different issues than that of CAP enlargement. In other words, their model is not designed for the study of agricultural policies and is developed in order to investigate the macro-economic effects of tax harmonisation and public expenditures restructuring resulting from the preparation process for EU integration. Thus, Bayar et al. (2004) focus on non-agricultural issues, and in their case agriculture is treated as one large aggregated sector (including forestry and fishing) associated with a SAM and modelling structure different to what would have been the case if the model were developed to assess more detailed agriculture-related economic impacts (e.g. land does not appear as a separate factor input into agriculture).

Furthermore, Romanian agriculture plays a substantial role in the country's overall transition process and distinguishes itself from that of other CEE countries through its sheer size in relative terms, absorbing a substantial amount of human resources and producing a significant volume of the country's total output. In other words, the high shares of agriculture in Romania's total area (62 percent), national product (14 percent), and total active labour force (40 percent), render the sector a salient dimension both for researchers and poliy-makers involved in agricultural development. Thus, the high importance of agriculture in the Romanian economy further argues in favour of an AGE approach to the detriment of partial equilibrium modelling.

The development of an AGE model with a focus on Romania's agricultural and food sectors intends to fill a gap in the modelling literature dealing with EU eastward expansion. The model developed in this paper is labelled GEMAR (General Equilibrium Model Applied to Romania) and aims to partially address the "black-box" critique frequently invoked by researchers criticising the modelling literature by presenting in details main steps undertaken in building the respective applied model. GEMAR should also be seen as a conceptual and theoretical explanation of the methodology employed in a previous study undertaken by Scrieciu (2004), though it comes at a relatively later stage. Scrieciu (2004) assesses using GEMAR in a slightly simplified version the economic impacts arising from incorporating the agricultural and food sectors into EU's customs union. Therefore, the model developed in this paper tackles an issue that is currently of considerable interest for researchers and policymakers involved in agriculture and economic development in the context of EU's next phase of enlargement that is due to include *inter alia* Romania. It intends to do so through further and more elaborate studies that make use of the respective model.

The paper is structured into five main sections. The next section presents a brief description of the approach and the main building steps involved in constructing GEMAR. Section 3 presents the salient assumptions underlying GEMAR and a detailed mathematical formulation underpinning the model's structure. Section 4 provides a simple application of the respective model by simulating two unilateral trade liberalisation scenarios. Finally, section 5 concludes and outlines further research intentions.

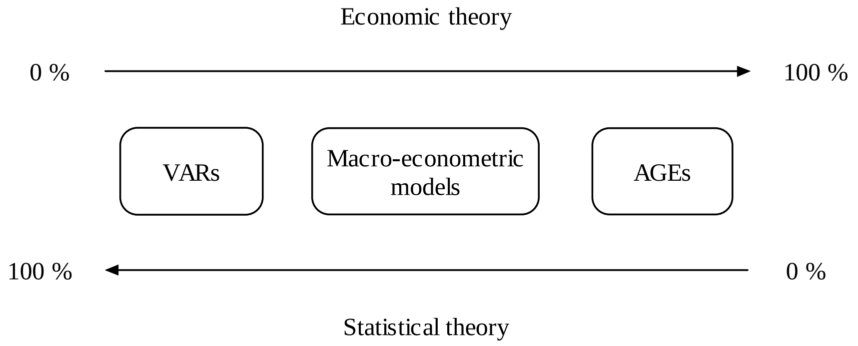
DESCRIPTION OF THE APPROACH AND DATABASE

General Issues Related to the AGE Methodology

Petersen (1997) argues that AGEs are endowed with a strong theoretical framework for which data are then fitted in, as opposed to Vector Autoregressive (VAR) models that attempt to find patterns and economic explanations in the large amount of data with which these are provided (Figure 1). The author then places macro-econometric models in between VARs and AGEs as these are based both on classical statistics and to some degree on economic theory. Neverthelessh the latter have not been very successful in investigating policy impacts on resource allocation and welfare, whilst Walrasian derived applied general equilibrium models provide an ideal set-up for analysing such effects (Shoven and Whalley, 1984). In other words, the authors clearly describe the aim of AGE modelling, which is "… to evaluate policy options by specifying production and demand parameters and incorporating data reflective of real economies."

Figure 1

Taxonomy of applied macroeconomic models



Source: Peterson, T.W. (1997), "An introduction to CGE-modelling and an illustrative application to Eastern European Integration with the EU". Note: AGE replaces the CGE abbreviation from the original figure to provide consistency in notation throughout the paper.

Standard general equilibrium models depict the workings of a perfect competitive market economy, where consumers and producers display an optimising behaviour (subject to budget, and respectively, production cost constraints), and where prices and quantities adjust to clear all commodity and factor markets. Economic equilibrium models formalised by Arrow and Debreu in the 1950s render a unique general equilibrium solution in competitive markets if they satisfy three equilibrium conditions (Mathiesen, 1985, restated in Paltsev, 2004):[9]

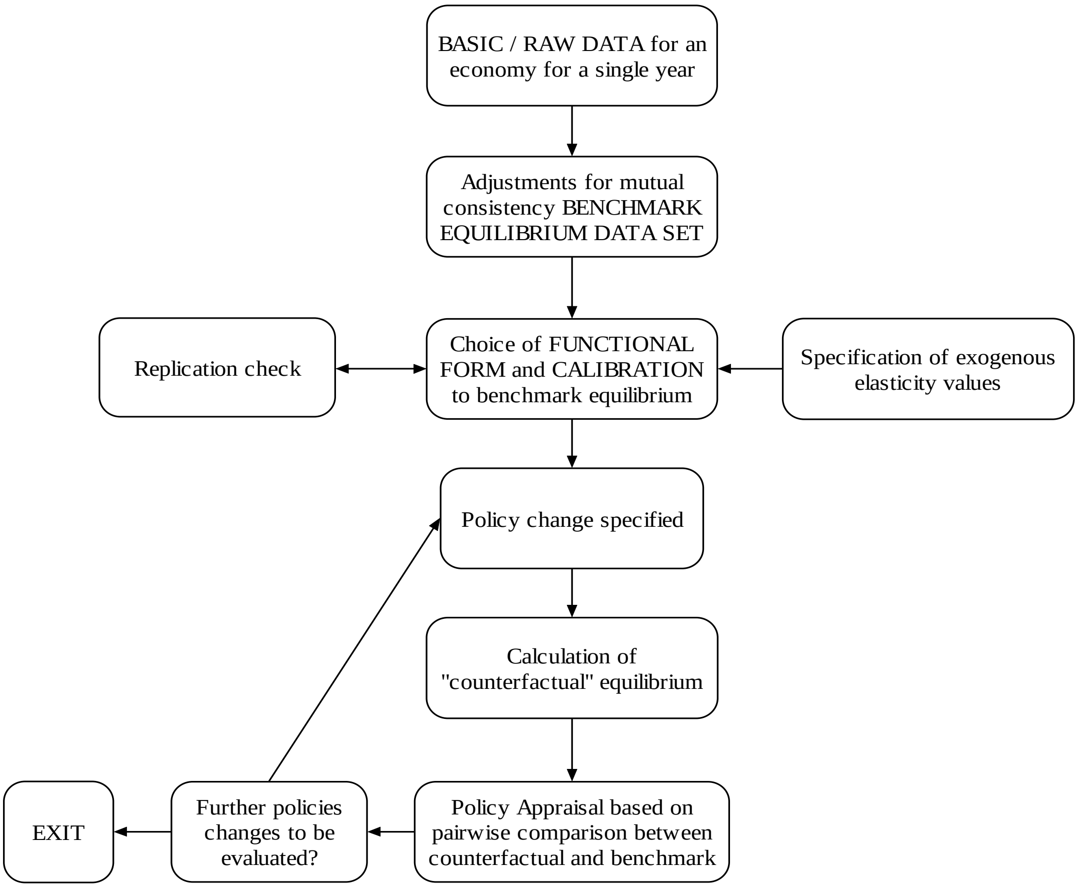
1. *Zero profit condition* requiring that any activity operating at a positive intensity must earn zero profit.
2. *Market clearance condition* requiring that supply and demand for any good / factor of production must balance.
3. *Income balance condition* requiring that for each economic agent the value of income must equal the value of factor endowments.

Applied general equilibrium models also rely on the above equilibrium conditions. They represent an extension of classical equilibrium analytical models in the sense that they are mostly policy driven and aim to provide numerical solutions to large multi-sectoral models.[10] The AGE model's main task is to simultaneously find equilibrium prices, quantities, and incomes of an economy where all economic flows are accounted for. In other words, they ensure that there is a “sink” for every “source” (Paltsev, 2004). Furthermore, they are capable of illustrating the respective economic flows in much more detail and complexity than analytical models, which can only afford to work in small dimensions. For instance, an applied GE framework can model several taxes that are applicable to different sectors within an economy, providing the modeller with significant detail regarding feedback effects of specific tax policy initiatives (Shoven and Whalley, 1984).

Showen and Whalley (1984) have clearly illustrated the necessary steps in building an AGE model and running policy simulations (Figure 2 above). First an organised dataset is required so that it consistently depicts an economy fulfilling the three main previously mentioned equilibrium conditions. The next step is to set the functional form of the modelled economy and to compute its parameters based upon the benchmark equilibrium values.

Figure 2

Flow chart associated with AGE-modelling



Source: Shoven, J. and J. Whalley, 1984, "Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey".

The latter procedure is known as calibration. Its purpose is to feed the calculated parameter values into the specified model that combined with exogenous elasticity values replicate the initial benchmark equilibrium. In other words, the replication check represents a test of verifying whether the model was correctly specified and parameters rightly calibrated. Finally, once the baseline data is replicated, various policy changes can be simulated, the associated counterfactual equilibria calculated, and the respective comparative-static analysis undertaken.

Romanian Data Organisation Under a SAM Format

AGE models usually take data for one year (base year) or an average of years for the economy under consideration from sources such as national accounts, input-output tables, trade statistics, balance of payments, and household surveys. The data are then organised into a double-counting book-keeping matrix whose corresponding columns and rows represent the expenditure and receipt accounts of economic agents, and whose total receipts (row sum) and total expenditures (column sum) corresponding to each account must balance. This is commonly known in the modelling literature as a Social Accounting Matrix (SAM). The SAM thus numerically illustrates "all the basic accounting identities which must hold for the economy to be in equilibrium" (Hertel, 1999). It provides the underlying consistent multi-sectoral economic data framework necessary to develop economy-wide models and to undertake policy analysis (Robinson et al., 2000).

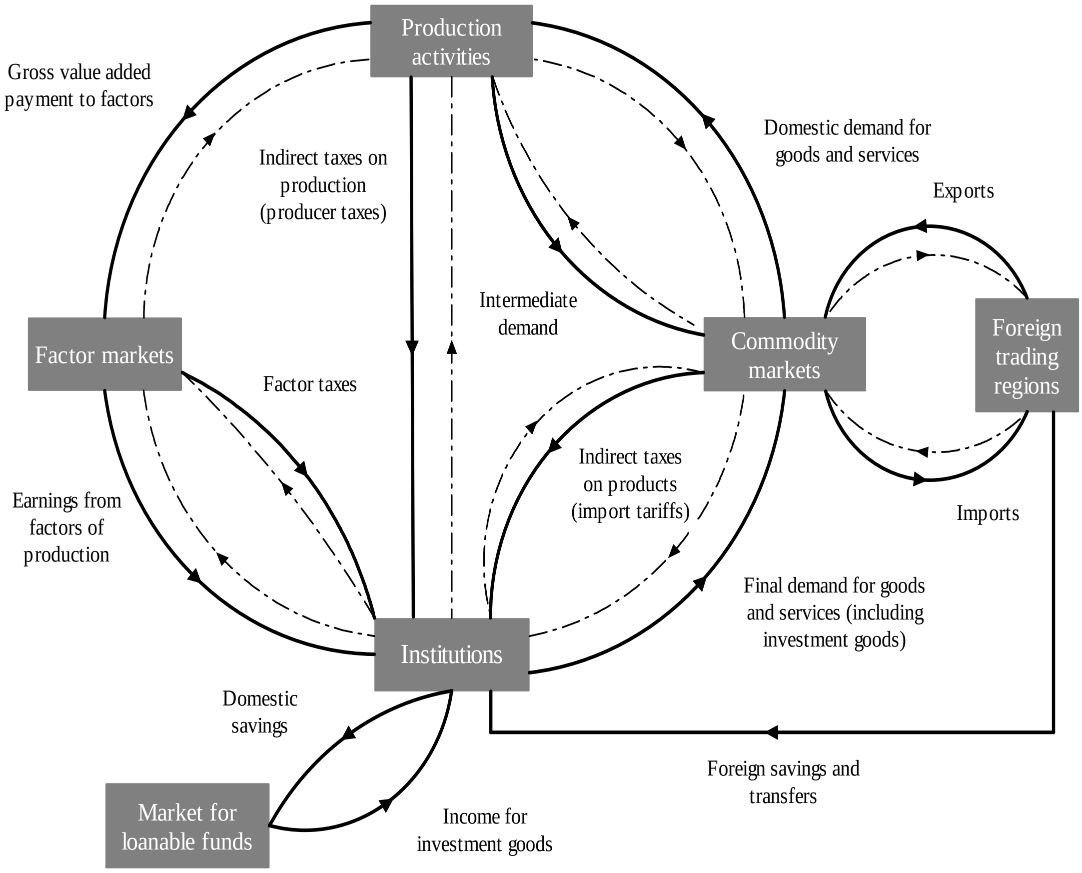
The numerical SAM employed in this model is based on 1997 data and is derived from a SAM for Romania developed for the EU-Commission by a team coordinated by Martin Banse (2001)[11]. A display of all the accounts considered by the SAM is made available in the appendix (see table A1 where the entry in the SAM table corresponding to row *i,* and column *j* indicates the receipt of account *i* originating from expenditure account *j*).

The following main modifications to the structure of the initial Banse (2001) SAM were made here:[12]

- An aggregation of the fifty-six sectors and their corresponding commodities from the Banse (2001) version to a level of twenty-three sectors (see table A2 in the appendix). Of these twenty-three sectors, eleven are agricultural and seven are food-processing activities. Such level of sectoral disaggregation in the SAM underpinning GEMAR has been chosen in order to deal with the agricultural related research questions that the model aims to address.
- Land as a further primary factor of production has been added to the matrix.
- The one rest of the world trading region block that figures in Banse (2001) has been split here into four foreign trading regions: the European Union (EU15), the ten Central and Eastern European countries (CEEC10) that recently joined the EU in 2004, Bulgaria (BG), and the Rest of the World (RoW). This was again undertaken so that it reflects the aim of GEMAR to assess economic impacts stemming from Romania joining EU structures.

The SAM can be schematically represented through a circular flow of incomes and their corresponding expenditures between various parts of the economy (figure 3). Income flows counter-clockwise from production activities to factor markets to institutions to commodity markets and back to production activities, whilst expenditures flow clockwise around the respective four main parts of the economy. Production activities transfer gross value added payments to land, labour and capital factor markets which in turn pay for factor earnings to corresponding factor owners, government and households, grouped under the label of institutions. The latter demand goods and services (including investment goods) and pay to commodity markets, which in turn transfer income to production activities for the goods and services supplied. In addition to this main flow of income there are other flows between production activities and commodity markets (intermediate demand), production activities and institutions (producer taxes), factor markets and institutions (factor taxes), commodity markets and institutions (product taxes / import tariffs). Thus, the main distortions present in the economy and captured in the SAM stem from taxing or subsidising[13] production activities and imposing tariffs on import flows.

Figure 3: Circular flow of income in an economy and their corresponding expenditures



Source: Authors' diagram

Notes: The flow of income is counter-clockwise (bolded line) and the corresponding flow of products and factor services is clockwise (dotted line)

Taxes on factors of production apply only to capital, but these are more likely to reflect the profits that accrue to the Romanian government from owning enterprises. Income also flows between foreign trade regions and commodity markets. The former receive income in exchange for the economy's imports, whilst the latter receive income from the economy's exports. Moreover, institutions receive further income from net foreign savings and transfers from abroad. These are used to finance an eventual trade deficit. Finally, income flows between institutions and the market for loanable funds, namely economic agents save part of their income that is made available for others to invest.

Further income flows not displayed in Figure 3 are considered in the database organised under a SAM format. These include income taxation from households to government, transfers from abroad to households, and transfers from government to households. It is worthwhile noting that changes in inventories and capital depreciation are also accounting for in the SAM.[14] Hence, goods supplied to the market that do not meet demand accumulate as inventories, whose value is deducted from the investment demand account. Capital depreciation is assumed to diminish the endowment value associated with the owners of the respective capital.

The Social Accounting Matrix thus provides the modeller with a benchmark equilibrium data set representing the Romanian economy in 1997.[15] This balanced data set is then used to derive the endogenous parameters, which are in turn employed in constructing the functional form of the modelled economy and conducting the associated replication check. The parts of the economy illustrated in Figure 3 are modelled in much more detail in the AGE model. Such modelling formulation and their associated assumptions are further discussed below.

PRESENTATION OF THE APPLIED GENERAL EQUILIBRIUM MODEL

Main Assumptions Underlying the Model

The AGE model for the Romanian economy is of single-country static nature and is based on Walrasian tradition and on the Arrow-Debreu simultaneous general economic equilibrium conditions. As noted above, the economy is disaggregated into twenty-three industries that produce goods and services by employing three primary factors of production and intermediate inputs. Capital is in its turn split into two components depending on whether it is under private or governmental ownership. All commodities and services are used both in production and consumption. The national economy has been further stylised to fulfil the following main assumptions that are more or less standardised in the AGE-modelling literature:

- Commodity market demands are dependent on all prices, are continuous and non-negative, and satisfy Walras' law.[16]
- The classical dichotomy between real and nominal variables or the money neutrality assumption holds: an increase in prices results in a proportionate increase in money profits with no effect on real activity, demand or any real variables. In other words, the zero homogeneity of demand functions coupled with the linear homogeneity of profits in prices implies that only relative prices affect consumer and producer behaviour, and that

the absolute level of prices has no effect on equilibrium outcome (Shoven and Whalley, 1984).

- Producers maximise profits subject to a constant returns to scale production technology and operate under perfect competition settings implying that the best they can do is breakeven at equilibrium prices, which they take as given.
- Each production sector displays a nested (hierarchical) production function structure. The technology in value added and intermediate aggregate inputs, is of Leontief type, meaning that the top-level elasticity of substitution between primary factors of production and intermediate inputs is assumed to be zero. The aggregator function for land, labour, and capital is of a linear-homogeneous Constant Elasticity of Substitution (CES) nature allowing for a certain degree of substitution between the respective primary factors of production. Intermediate inputs are aggregated values of inputs of domestically produced and imported commodities.
- Land enters as a primary factor of production only in agriculture, whilst labour and capital (with the exception of government capital which is sector specific) are mobile across sectors. The assumption that production factors are allowed to reallocate between alternative uses as a response to some exogenous events corresponds to a medium-term analysis (van Tongeren et al., 2001).[17]
- Resources, except government capital are not fully employed. In other words, the supply of factors is endogenised by the existence of unemployment for each factor of production. This is accounted for by assuming a Phillips curve inverse relationship between unemployment and real returns to the factor under consideration. Government capital is fully employed and its total endowment is exogenously fixed.
- There are two main institutions involved in the model: a government and a representative household.
- Exchange rates are flexible, whilst foreign prices are exogenously set in the baseline, reflecting the inability of Romania to influence world prices by altering its trading position (the small open economy assumption). Hence, the terms of trade faced by the small country do not change in the baseline (Södersten and Reed, 1994).
- A "double Armington" assumption on bilateral trade streams is employed. The "double" approach reflects an Armington aggregation at the border, where products are differentiated according not only to their region of origin (the original Armington assumption) but also to their market destination. These apply in a two-stage manner sometimes referred to as a "two-tier decision process" (Donnelly et al., 2004). First

domestically produced goods are differentiated from imports, and respectively, goods produced for domestic use are differentiated from exports. Second, imports, and respectively exports, are imperfect substitutes across the four foreign trading regions. The Armington assumption solves the problem of cross-hauling[18] encountered in trade data and allows for intra-industry trade, which under perfect competition is inconsistent with traditional Hecksher-Ohlin trade theory (Petersen, 1997).

- There are two main macro closure rules[19] that differentiate the model from purely classical "Walrasian" types.[20] First there is a macroeconomic neo-classical closure where investments are endogenous and adjust to accommodate changes in savings. Thus, the trade balance in foreign currency is exogenously fixed so that any change in investment is financed out of national savings. This allows for the existence of a trade deficit and helps to solve for the fundamental indeterminacy of investments in comparative static models. However, investments in a static model only influence aggregate demand and do not impact productive capacities or the availability of capital within the national economy. Second, there is a government closure rule that allows for a budget deficit whereby government consumption is kept fixed and only transfers to households change with budgetary income fluctuations. The adoption of this closure rule is also supported by the fact that government consumption is usually taken to reflect mostly decisions of policy makers rather than any specific economic mechanism (Zalai, 1998). In addition, factor markets are closed by changes in factor unemployment levels, whilst factor supplies are made endogenous.

Hence, the model does include crucial elements not considered in orthodox economic theory such as national differentiation of products, intra-industry trade, intermediate consumption, the existence of a trade deficit, and the existence of unemployment. In addition and most importantly, the general equilibrium modelling accounts for the generality of the economic analysis by simultaneously looking at markets for many different products in contrast with trade theories that usually investigate resource allocation, specialisation and welfare effects mainly in terms of partial equilibrium by considering the market for a single commodity.

Model Formulation

The model is formulated and solved using the specialist software MPSGE as a GAMS subsystem. GAMS (Generalized Algebraic Modelling System) is a mathematical modelling language that was developed by Alex Meeraus in the 1980s to solve linear, nonlinear and integer programming problems (Rutherford, 1999). MPSGE (Mathematical Programming System for General Equilibrium Analysis) uses GAMS as an interface and has been designed by Thomas Rutherford in 1987 to provide "a short-hand [non-algebraic] representation for the complicated systems of nonlinear inequalities which underly general equilibrium models" (Rutherford, 1999). As opposed to GAMS that is applicable in several disciplines, MPSGE has a limited role and reflects only a concise representation of Arrow-Debreu economic equilibrium models. Nonetheless, as the author notes, MPSGE makes AGE accessible to economists who would be interested in the insights that are to be offered by such models and wish to avoid complex algebraic formulations.

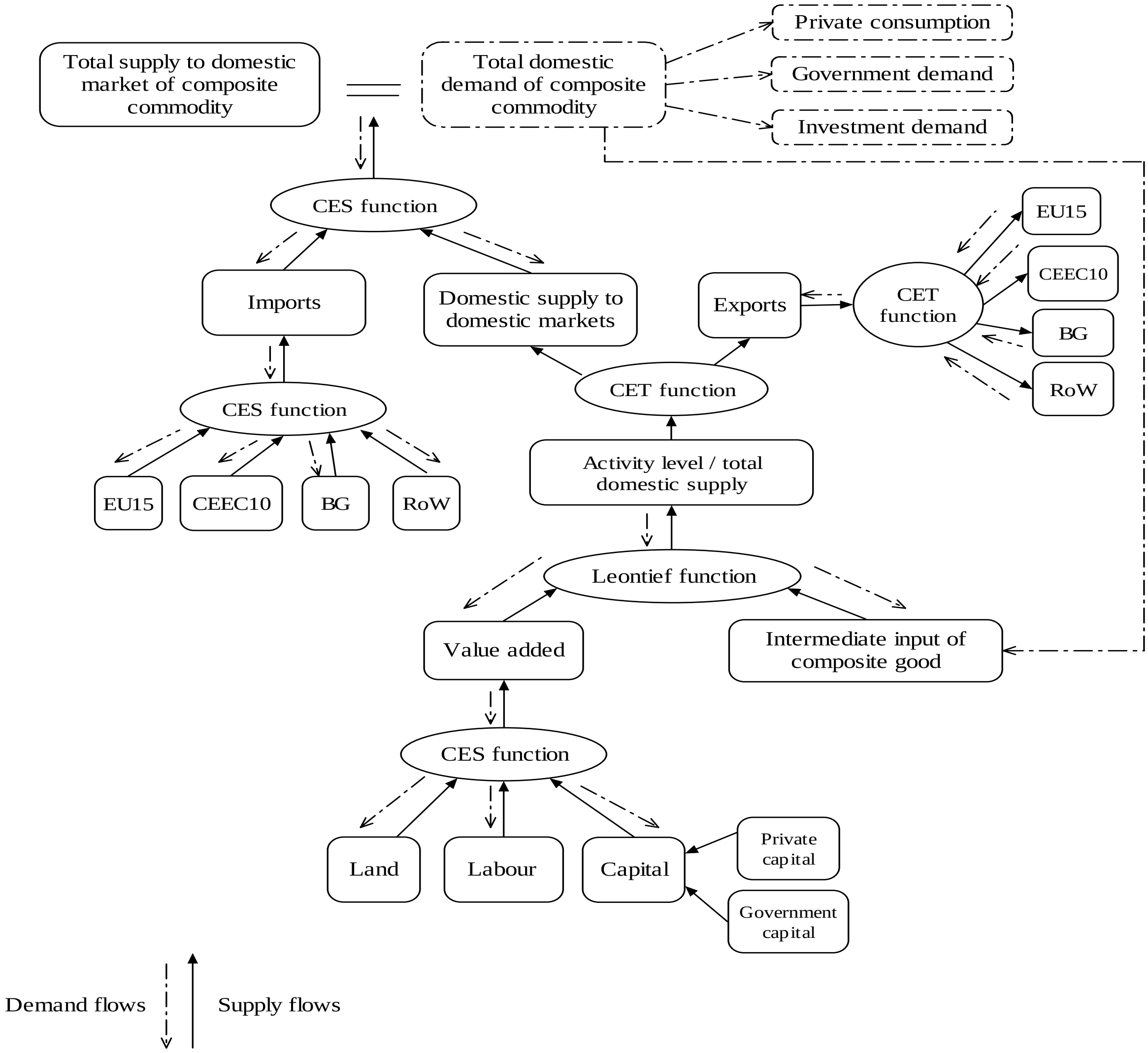
This section further investigates details associated with each main part of the economy modelled in this paper and the functional form the model takes. First, the algebraic relations describing producer behaviour and the structure of market supplies including linkages with foreign trade are discussed. Second, the aggregate demand composed of demand for domestically produced goods and imports, is depicted. The model turns afterwards towards the structure of other non-producing activities followed by trade and the balance of payments equations. The consumption behaviour of the representative household and government is then presented. The modelling of foreign savings comes next. And finally, the equilibrium conditions that both factor and commodity markets clear so that demand equals supply are displayed.

Production Activities and Supply Structure

The explanation of the model structure starts off with a graphical depiction (Figure 4) of the supply, demand and foreign trade inter-linkages that are captured by the model. However, in order to better understand how the model analytically works, the main mathematical relationships and functional forms are displayed below.

Figure 4

Supply, demand and foreign trade inter -linkages captured in the model



Source: Own diagram

From the above diagram, one can notice that in each sector $i \in S$ (where S={1,2….,23}), production activities are modelled using a two-level nested production function that employs the constant elasticity of substitution (CES) family of functions in value added. These permit a high degree of flexibility in model specification and seem to display the most appropriate functional form for the global representation of technologies in economic equilibrium analysis (Perroni and Rutherford, 1998). The authors test the global properties of four functional forms and conclude that nested CES are the best in preserving local calibration information and display the most regular representation with clear advantages for AGE analysis. Each activity i produces one type of commodity j meaning that no joint production is assumed.

At the first top level, the intermediate input composite good and value added are assumed to be perfect complementary according to a Leontief-fixed coefficients function:

$$AL_i = \min\left\{\frac{QVA_i}{a_i^{QVA}}, \frac{QII_{j,i}}{a_{j,i}^{QII}}\right\} \qquad i, j \in S$$

where AL_i represents the activity level of production associated with sector *i*; QVA_i is the quantity of value added in sector *i*; $QII_{j,i}$ is the quantity of intermediate input of composite good *j* in sector *i* which represents an aggregate value of inputs domestically produced and imported; and a_i^{QVA} and $a_{j,i}^{QII}$ are calibrated fixed coefficients (usually referred to as efficiency parameters) of real value added, and respectively, intermediate input in output. At the second level, factors of production are aggregated into value added by means of a CES function:

$$QVA_i = a_i\left[\alpha_i^{QLD} QLD_i^{\left(\frac{\sigma_i-1}{\sigma_i}\right)} + \alpha_i^{QL} QL_i^{\left(\frac{\sigma_i-1}{\sigma_i}\right)} + \alpha_i^{QK} QK_i^{\left(\frac{\sigma_i-1}{\sigma_i}\right)} + \alpha_i^{QGK} QGK_i^{\left(\frac{\sigma_i-1}{\sigma_i}\right)}\right]^{\left(\frac{\sigma_i}{\sigma_i-1}\right)} \qquad i \in S$$

where QLD_i, QL_i, QK_i, QGK_i represent the quantity of land, labour, private and government capital[21] employed in each sector *i*; a_i is a calibrated shift coefficient linked with each activity *i*; α_i^{QLD}, α_i^{QL}, α_i^{QK}, α_i^{QGK} are calibrated share coefficients associated with each factor of production such that $\alpha_i^{QLD} + \alpha_i^{QL} + \alpha_i^{QK} + \alpha_i^{QGK} = 1$ for each *i*; and σ_i constitutes the elasticity of substitution between land, labour, and the two types of capital. Land inputs into production (QLD_i) take non-zero values only if employed in agriculture. CES values are lower for primaries than for processed goods meaning that factors of production in agriculture are less responsive to changes in relative returns as compared to those employed in manufactures (see table A3 in the appendix for actual values employed in the model). It is important to emphasise that the elasticity of substitution in value added is a key parameter in the production behaviour of industries. This is because it reflects the percentage change in relative quantities of factors of production demanded by producers in response to a one percent change in their relative returns. In addition, the model assumes that land, private and government capital, and labour substitute between each other within a given sector with the same elasticity value. In other words, if returns to land happen to increase by 10% relative to (private and government) capital, and 5% relative to labour, then agricultural producers would shift away from the more expensive land to the employment of more capital and labour, with the ratio of capital to land, and labour to land, increasing by 10% times σ_i, and respectively, 5% times σ_i.

Producers adopt a profit maximising behaviour subject to their constraint that total post-tax revenue equals total costs:

$$P_i^{AL} AL_i (1 - tp_i) = P_i^{VA} QVA_i + \sum_j P_j QII_{j,i} , \qquad i, j \in S$$

where the left part of the equation illustrates the revenue to be maximised, P_i^{AL} being the producer price, and tp_i the tax on production. The right hand side of the above equation represents the total costs that producers face, P_i^{VA} reflecting the price of value added, and P_j being the price of the intermediate input composite (which is equal to the Armington price displayed in the aggregate demand equations). In its turn, the price times quantity of value added is equivalent to the sum of returns to each factor of production:

$$P_i^{VA} QVA_i = r_{LD} QLD_i + wQL_i + r_K QK_i + r_i^{GK} QGK_i \qquad i \in S$$

where, r_{LD} is the rate of return to land, w the wage rate accruing to labour, and r_K and r_i^{GK} the rate of returns to private and government capital. Industries produce up to the point where marginal costs equal marginal products for each input employed in production. This combined with the perfect competition assumption (free exit and free entry) satisfy one of the model's equilibrium conditions stating that any activity operating at a positive intensity must earn zero profit (i.e. the zero profit condition). However, normal operating profits are accounted for and are given by the returns to capital ($r_K QK_i$). The producer optimising behaviour and the equations displayed above lead to the derivation of the following price and input quantity demand equations:

$$P_i^{AL} (1 - tp_i) = a_i^{QVA} P_i^{VA} + \sum_j a_{j,i}^{QII} P_j \qquad i, j \in S$$

(1)

$$P_i^{VA} = \frac{1}{a_i} \left[\alpha_i^{QLD} (r_{LD})^{1-\sigma_i} + \alpha_i^{QL} (w)^{1-\sigma_i} + \alpha_i^{QK} (r_K)^{1-\sigma_i} + \alpha_i^{QGK} \left(r_i^{GK} \right)^{1-\sigma_i} \right]^{\left(\frac{1}{1-\sigma_i}\right)} \qquad i \in S \qquad (2)$$

$$QVA_i = a_i^{QVA} AL_i \qquad i \in S$$

(3)

$$QII_{j,i} = a_{j,i}^{QII} AL_i \qquad i, j \in S$$

(4)

$$QLD_i = \left(\frac{QVA_i}{a_i}\right)\left(\frac{\alpha_i^{QLD}}{r_{LD}}\right)^{\sigma_i} \left[\left(\alpha_i^{QLD}\right)^{\sigma_i}\left(r_{LD}\right)^{1-\sigma_i} + \left(\alpha_i^{QL}\right)^{\sigma_i}\left(w\right)^{1-\sigma_i} + \left(\alpha_i^{QK}\right)^{\sigma_i}\left(r_K\right)^{1-\sigma_i} + \left(\alpha_i^{QGK}\right)^{\sigma_i}\left(r_i^{GK}\right)^{1-\sigma_i}\right]^{\left(\frac{\sigma_i}{1-\sigma_i}\right)}$$

$i \in S$ (5)

$$QL_i = \left(\frac{QVA_i}{a_i}\right)\left(\frac{\alpha_i^{QL}}{w}\right)^{\sigma_i} \left[\left(\alpha_i^{QLD}\right)^{\sigma_i}\left(r_{LD}\right)^{1-\sigma_i} + \left(\alpha_i^{QL}\right)^{\sigma_i}\left(w\right)^{1-\sigma_i} + \left(\alpha_i^{QK}\right)^{\sigma_i}\left(r_K\right)^{1-\sigma_i} + \left(\alpha_i^{QGK}\right)^{\sigma_i}\left(r_i^{GK}\right)^{1-\sigma_i}\right]^{\left(\frac{\sigma_i}{1-\sigma_i}\right)}$$

$i \in S$ (6)

$$QK_i = \left(\frac{QVA_i}{a_i}\right)\left(\frac{\alpha_i^{QK}}{r_K}\right)^{\sigma_i} \left[\left(\alpha_i^{QLD}\right)^{\sigma_i}\left(r_{LD}\right)^{1-\sigma_i} + \left(\alpha_i^{QL}\right)^{\sigma_i}\left(w\right)^{1-\sigma_i} + \left(\alpha_i^{QK}\right)^{\sigma_i}\left(r_K\right)^{1-\sigma_i} + \left(\alpha_i^{QGK}\right)^{\sigma_i}\left(r_i^{GK}\right)^{1-\sigma_i}\right]^{\left(\frac{\sigma_i}{1-\sigma_i}\right)}$$

$i \in S$

(7)

$$QGK_i = \left(\frac{QVA_i}{a_i}\right)\left(\frac{\alpha_i^{QGK}}{r_i^{GK}}\right)^{\sigma_i} \left[\left(\alpha_i^{QLD}\right)^{\sigma_i}\left(r_{LD}\right)^{1-\sigma_i} + \left(\alpha_i^{QL}\right)^{\sigma_i}\left(w\right)^{1-\sigma_i} + \left(\alpha_i^{QK}\right)^{\sigma_i}\left(r_K\right)^{1-\sigma_i} + \left(\alpha_i^{QGK}\right)^{\sigma_i}\left(r_i^{GK}\right)^{1-\sigma_i}\right]^{\left(\frac{\sigma_i}{1-\sigma_i}\right)}$$

$i \in S$

(8)

Further on, part of the produced output is supplied to the domestic market, and part of it is exported abroad according to a constant elasticity of transformation function that is mathematically equivalent to the CES function:

$$AL_i = b_i \left[\beta_i^{QD} QD_i^{\left(\frac{\theta_i - 1}{\theta_i}\right)} + (1-\beta_i^{QD}) X_i^{\left(\frac{\theta_i - 1}{\theta_i}\right)}\right]^{\left(\frac{\theta_i}{\theta_i - 1}\right)} \qquad i \in S$$

where QD_i represents that part of output that is supplied to the domestic market; X_i is the proportion of production being exported; b_i is a calibrated shift coefficient; β_i^{QD} and 1-β_i^{QD} are calibrated share coefficients associated with supply to domestic, and respectively, foreign markets (some values for these parameters as well as other calibrated share parameters are displayed in table A6 in the appendix); and θ_i constitutes the constant elasticity of transformation (see table A4 in the appendix for actual values employed in the model). The latter is again of crucial importance to producers' behaviour and it reflects to what extent they are readily to switch sales between domestic and export markets. The existence of heterogeneity between export sales and domestic sales could be attributed not only to differences in the quality of goods, but also to the level of aggregation. For example, a high level of aggregation (beverages and tobacco, or textiles, wearing apparel and leather products) is more likely to generate an aggregate good that from its composition point of view differs between export and domestic markets. Producers maximise once again total supply subject this time to the constraint that total revenue received by selling the whole supply equals the revenue gained from selling to each market:

$$P_i^{AL} AL_i = P_i^D QD_i + P_i^X X_i \qquad i \in S$$

where P_i^D and P_i^X are the prices associated with the output sold on the domestic, and respectively, foreign markets. Thus, the following (dual) price and output supply equations are derived:

$$P_i^{AL} = \frac{1}{b_i}\left[\beta_i^{QD}\left(P_i^D\right)^{1-\theta_i} + \left(1-\beta_i^{QD}\right)\left(P_i^X\right)^{1-\theta_i}\right]^{\left(\frac{1}{1-\theta_i}\right)} \qquad i \in S$$

(9)

$$QD_i = \left(\frac{AL_i}{b_i}\right)\left(\frac{\beta_i^{QD}}{P_i^D}\right)^{\theta_i}\left[\left(\beta_i^{QD}\right)^{\theta_i}\left(P_i^D\right)^{1-\theta_i} + \left(1-\beta_i^{QD}\right)^{\theta_i}\left(P_i^X\right)^{1-\theta_i}\right]^{\left(\frac{\theta_i}{1-\theta_i}\right)} \qquad i \in S \qquad (10)$$

$$X_i = \left(\frac{AL_i}{b_i}\right)\left(\frac{(1-\beta_i^{QD})}{P_i^X}\right)^{\theta_i}\left[\left(\beta_i^{QD}\right)^{\theta_i}\left(P_i^D\right)^{1-\theta_i} + \left(1-\beta_i^{QD}\right)^{\theta_i}\left(P_i^X\right)^{1-\theta_i}\right]^{\left(\frac{\theta_i}{1-\theta_i}\right)} \qquad i \in S \qquad (11)$$

Exports are in turn subject to a CET function across the four trading regions captured within the model. In other words, part of the exported output is supplied to the initial European Union members (EU15), part of it to the Central and Eastern European Countries (CEEC10), some to Bulgaria (BG) and the remainder to the Rest of the World (RoW) according to a constant elasticity of transformation function:

$$X_i = c_i\left[\chi_i^{XEU} XEU_i^{\left(\frac{2\theta_i-1}{2\theta_i}\right)} + \chi_i^{XCEE} XCEE_i^{\left(\frac{2\theta_i-1}{2\theta_i}\right)} + \chi_i^{XBG} XBG_i^{\left(\frac{2\theta_i-1}{2\theta_i}\right)} + \chi_i^{XRW} XRW_i^{\left(\frac{2\theta_i-1}{2\theta_i}\right)}\right]^{\left(\frac{2\theta_i}{2\theta_i-1}\right)}$$

$i \in S$

where XEU_i , $XCEE_i$, XBG_i , and XRW_i represent that part of exported output that is supplied to EU15, CEEC10, BG, and respectively, RoW; c_i is a calibrated shift coefficient; χ_i^{XEU}, χ_i^{XCEE}, χ_i^{XBG}, and χ_i^{XRW} are calibrated share coefficients associated with supply to each of the four foreign trading regions; and $2\theta_i$ constitutes the constant elasticity of transformation that differentiates exports according to their destination. The "rule-of-two" with reference to CET values across trading regions has been employed as explained below in the case of Armington elasticities. Under the condition that revenue received from all exports matches the sum of revenues gained from each foreign market block:

$$P_i^X X_i = P_i^{XEU} XEU_i + P_i^{XCEE} XCEE_i + P_i^{XBG} XBG_i + P_i^{XRW} XRW_i \qquad i \in S$$

where P_i^{XEU}, P_i^{XCEE}, P_i^{XBG}, and P_i^{XRW} are the prices associated with the quantities supplied to each of the four trading regions, price and supply equations are again derived:

$$P_i^X = \frac{1}{c_i}\left[\chi_i^{XEU}\left(P_i^{XEU}\right)^{1-2\theta_i} + \chi_i^{XCEE}\left(P_i^{XCEE}\right)^{1-2\theta_i} + \chi_i^{XBG}\left(P_i^{XBG}\right)^{1-2\theta_i} + \chi_i^{XRW}\left(P_i^{XRW}\right)^{1-2\theta_i}\right]^{\left(\frac{1}{1-2\theta_i}\right)}$$

$$i \in S \qquad (12)$$

$$XEU_i = \left(\frac{X_i}{c_i}\right)\left(\frac{\chi_i^{XEU}}{P_i^{XEU}}\right)^{2\theta_i}\left[\left(\chi_i^{XEU}\right)^{2\theta_i}\left(P_i^{XEU}\right)^{1-2\theta_i} + \left(\chi_i^{XCEE}\right)^{2\theta_i}\left(P_i^{XCEE}\right)^{1-2\theta_i} + \left(\chi_i^{XBG}\right)^{2\theta_i}\left(P_i^{XBG}\right)^{1-2\theta_i} + \left(\chi_i^{XRW}\right)^{2\theta_i}\left(P_i^{XRW}\right)^{1-2\theta_i}\right]^{\left(\frac{2\theta_i}{1-2\theta_i}\right)}$$

$$i \in S \qquad (13)$$

$$XCEE_i = \left(\frac{X_i}{c_i}\right)\left(\frac{\chi_i^{XCEE}}{P_i^{XCEE}}\right)^{2\theta_i}\left[\left(\chi_i^{XEU}\right)^{2\theta_i}\left(P_i^{XEU}\right)^{1-2\theta_i} + \left(\chi_i^{XCEE}\right)^{2\theta_i}\left(P_i^{XCEE}\right)^{1-2\theta_i} + \left(\chi_i^{XBG}\right)^{2\theta_i}\left(P_i^{XBG}\right)^{1-2\theta_i} + \left(\chi_i^{XRW}\right)^{2\theta_i}\left(P_i^{XRW}\right)^{1-2\theta_i}\right]^{\left(\frac{2\theta_i}{1-2\theta_i}\right)}$$

$$i \in S \qquad (14)$$

$$XBG_i = \left(\frac{X_i}{c_i}\right)\left(\frac{\chi_i^{XBG}}{P_i^{XBG}}\right)^{2\theta_i}\left[\left(\chi_i^{XEU}\right)^{2\theta_i}\left(P_i^{XEU}\right)^{1-2\theta_i} + \left(\chi_i^{XCEE}\right)^{2\theta_i}\left(P_i^{XCEE}\right)^{1-2\theta_i} + \left(\chi_i^{XBG}\right)^{2\theta_i}\left(P_i^{XBG}\right)^{1-2\theta_i} + \left(\chi_i^{XRW}\right)^{2\theta_i}\left(P_i^{XRW}\right)^{1-2\theta_i}\right]^{\left(\frac{2\theta_i}{1-2\theta_i}\right)}$$

$$i \in S \qquad (15)$$

$$XRW_i = \left(\frac{X_i}{c_i}\right)\left(\frac{\chi_i^{XRW}}{P_i^{XRW}}\right)^{2\theta_i}\left[\left(\chi_i^{XEU}\right)^{2\theta_i}\left(P_i^{XEU}\right)^{1-2\theta_i} + \left(\chi_i^{XCEE}\right)^{2\theta_i}\left(P_i^{XCEE}\right)^{1-2\theta_i} + \left(\chi_i^{XBG}\right)^{2\theta_i}\left(P_i^{XBG}\right)^{1-2\theta_i} + \left(\chi_i^{XRW}\right)^{2\theta_i}\left(P_i^{XRW}\right)^{1-2\theta_i}\right]^{\left(\frac{2\theta_i}{1-2\theta_i}\right)}$$

$$i \in S \qquad (16)$$

Aggregate demand

Aggregate demand (AD_i) is composed of demand for domestically produced goods and demand for imports (top left corner of Figure 4). The resulting demanded composite good is subject to a CES function:

$$AD_i = d_i \left[\delta_i^{DD} DD_i^{\left(\frac{\rho_j - 1}{\rho_j}\right)} + \left(1 - \delta_i^{DD}\right) M_i^{\left(\frac{\rho_i - 1}{\rho_i}\right)} \right]^{\left(\frac{\rho_i}{\rho_i - 1}\right)} \qquad i \in S$$

where DD_i and M_i represent the demand for domestic commodities, and respectively, imports; d_i is a calibrated shift coefficient; δ_i^{DD} and $\left(1 - \delta_i^{DD}\right)$ are calibrated share coefficients associated with demand for domestic goods and the demand for imported varieties; and ρ_i represents the Armington constant elasticity of substitution (see table A4 in the appendix for actual values employed in the model). The latter represents another crucial parameter of the model that determines to what extent imported goods differ from those domestically produced. A high (low) CES value would reflect a low (high) level of heterogeneity between the two categories. A high (low) CES value would also mean that changes in import prices impact to a larger (lesser) extent changes in domestic prices.

Aggregate consumption is maximised subject to the constraint that total expenditures equal the sum of expenditures on domestically produced and imported commodities:

$$P_i \, AD_i = P_i^D DD_i + P_i^M M_i \qquad i \in S$$

where P_i is the aggregate Armington main price, and P_i^D and P_i^M are the prices associated with demand for domestic goods, and respectively, demand for imports. Hence, the following price and demand equations are derived:

$$P_i = \frac{1}{d_i} \left[\delta_i^{DD} \left(P_i^D\right)^{1-\rho_j} + \left(1 - \delta_i^{DD}\right)\left(P_i^M\right)^{1-\rho_i} \right]^{\left(\frac{1}{1-\rho_i}\right)} \qquad i \in S$$

(17)

$$DD_i = \left(\frac{AD_i}{d_j}\right)\left(\frac{\delta_i^{DD}}{P_i^D}\right)^{\rho_j} \left[\left(\delta_i^{DD}\right)^{\rho_j} \left(P_i^D\right)^{1-\rho_i} + \left(1 - \delta_i^{DD}\right)^{\rho_i} \left(P_i^M\right)^{1-\rho_{ij}} \right]^{\left(\frac{\rho_i}{1-\rho_i}\right)} \qquad i \in S$$

(18)

$$M_i = \left(\frac{AD_i}{d_j}\right)\left(\frac{1 - \delta_i^{DD}}{P_i^M}\right)^{\rho_i} \left[\left(\delta_i^{DD}\right)^{\rho_{ij}} \left(P_i^D\right)^{1-\rho_i} + \left(1 - \delta_i^{DD}\right)^{\rho_i} \left(P_i^M\right)^{1-\rho_{ij}} \right]^{\left(\frac{\rho_i}{1-\rho_i}\right)} \qquad i \in S \qquad (19)$$

In addition, the demand for total imports is composed in its turn of demand for imports from each of the four trading regions reflecting a so-called "two-tier decision process" (Donnelly et al., 2004). The first tier constitutes the substitution between domestic and foreign commodity, whilst the second tier is among foreign suppliers of the respective type of commodity. The second tier is thus also shaped by a CES function:

$$M_i = e_i\left[\varepsilon_i^{MEU} MEU_i^{\left(\frac{2\rho_i-1}{2\rho_i}\right)} + \varepsilon_i^{MCEE} MCEE_i^{\left(\frac{2\rho_i-1}{2\rho_i}\right)} + \varepsilon_i^{MBG} MBG_i^{\left(\frac{2\rho_i-1}{2\rho_i}\right)} + \varepsilon_i^{MRW} MRW_i^{\left(\frac{2\rho_i-1}{2\rho_{ij}}\right)}\right]^{\left(\frac{2\rho_i}{2\rho_i-1}\right)}$$

$i \in S$

where MEU_i, $MCEE_i$, MBG_i and MRW_i represent demands for imports from each trading region; e_i is a calibrated shift coefficient; ε_i^{MEU}, ε_i^{MCEE}, ε_i^{MBG} and ε_i^{MRW} are calibrated share coefficients such that they add up to 1; and $2\rho_i$ represents the Armington constant elasticity of substitution. The latter is actually assumed to be double the elasticity parameter (ρ) associated with the CES function distinguishing between domestically produced commodities and goods imported from abroad. This convention is referred to in the literature as "the rule-of-two" that has been observed in Jomini et al. (1991) and employed in the latest revision of Armington elastictities of substitution by Donnelly et al. (2004).

Expenditures on imported goods should equal the sum of expenditures on imports from each region: $P_i^M M_i = P_i^{MEU} MEU_i + P_i^{MCEE} MCEE_i + P_i^{MBG} MBG_i + P_i^{MRW} MRW_i$ $\quad i \in S$

where P_i^{MEU}, P_i^{MCEE}, P_i^{MBG}, and P_i^{MRW} are the tariff-inclusive prices associated with imports from each of the four trading regions. The resulting price and demand equations are:

$$P_i^M = \frac{1}{e_i}\left[\varepsilon_i^{MEU}\left(P_i^{MEU}\right)^{1-2\rho_i} + \varepsilon_i^{MCEE}\left(P_i^{MCEE}\right)^{1-2\rho_{ij}} + \varepsilon_i^{MBG}\left(P_i^{MBG}\right)^{1-2\rho_i} + \varepsilon_i^{MRW}\left(P_i^{MRW}\right)^{1-2\rho_i}\right]^{\left(\frac{1}{1-2\rho_i}\right)}$$

$i \in S$

(20)

$$MEU_i = \left(\frac{M_i}{e_i}\right)\left(\frac{\varepsilon_i^{MEU}}{P_i^{MEU}}\right)^{2\rho_i}\left[\left(\varepsilon_i^{MEU}\right)^{2\rho_{ij}}\left(P_i^{MEU}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MCEE}\right)^{2\rho_i}\left(P_i^{MCEE}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MBG}\right)^{2\rho_i}\left(P_i^{MBG}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MRW}\right)^{2\rho_i}\left(P_i^{MRW}\right)^{1-2\rho_i}\right]^{\left(\frac{2\rho_i}{1-2\rho_i}\right)}$$

$i \in S$

(21)

$$MCEE_i = \left(\frac{M_i}{e_i}\right)\left(\frac{\varepsilon_i^{MCEE}}{P_i^{MCEE}}\right)^{2\rho_i}\left[\left(\varepsilon_i^{MEU}\right)^{2\rho_{ij}}\left(P_i^{MEU}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MCEE}\right)^{2\rho_i}\left(P_i^{MCEE}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MBG}\right)^{2\rho_i}\left(P_i^{MBG}\right)^{1-2\rho_i} + \left(\varepsilon_i^{MRW}\right)^{2\rho_i}\left(P_i^{MRW}\right)^{1-2\rho_i}\right]^{\left(\frac{2\rho_i}{1-2\rho_i}\right)}$$

$i \in S$

(22)

$$MBG_i = \left(\frac{M_i}{e_i}\right)\left(\frac{\varepsilon_i^{MBG}}{P_i^{MBG}}\right)^{2\rho_i}\left[\left(\varepsilon_i^{MEU}\right)^{2\rho_{ij}}\left(P_i^{MEU}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MCEE}\right)^{2\rho_i}\left(P_i^{MCEE}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MBG}\right)^{2\rho_i}\left(P_i^{MBG}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MRW}\right)^{2\rho_i}\left(P_i^{MRW}\right)^{1-2\rho_i}\right]^{\left(\frac{2\rho_i}{1-2\rho_i}\right)} \quad i \in S$$

(23)

$$MRW_i = \left(\frac{M_i}{e_i}\right)\left(\frac{\varepsilon_i^{MRW}}{P_i^{MRW}}\right)^{2\rho_i}\left[\left(\varepsilon_i^{MEU}\right)^{2\rho_{ij}}\left(P_i^{MEU}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MCEE}\right)^{2\rho_i}\left(P_i^{MCEE}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MBG}\right)^{2\rho_i}\left(P_i^{MBG}\right)^{1-2\rho_i}+\left(\varepsilon_i^{MRW}\right)^{2\rho_i}\left(P_i^{MRW}\right)^{1-2\rho_i}\right]^{\left(\frac{2\rho_i}{1-2\rho_i}\right)} \quad i \in S$$

(24)

Trade and balance of payments

Exporting and importing activities are also modelled in a similar fashion to the production and non-production activities. The main difference is that both exports and imports associated with each commodity purchase only one type of input. In other words, exporting activities purchase exports and produce foreign exchange, whilst importing activities consume foreign exchange and produce imports. Since Romania is assumed to be a small open economy with respect to its trading partners, it faces export and import prices that are fixed in terms of world prices. Thus, export and import quantities associated with each trading region take any value such that domestic prices for each good *i* equals the world price times a single exchange rate (P^{FE}).

$$P_i^{XEU} = P^{FE}\,\overline{WP_i^{XEU}} \quad i \in S$$

(25)

$$P_i^{XCEE} = P^{FE}\,\overline{WP_i^{XCEE}} \quad i \in S$$

(26)

$$P_i^{XBG} = P^{FE}\,\overline{WP_i^{XBG}} \quad i \in S$$

(27)

$$P_i^{XRW} = P^{FE}\,\overline{WP_i^{XRW}} \quad i \in S$$

(28)

$$P_i^{MEU} = \left(1 + tm_i^{EU}\right)P^{FE}\,\overline{WP_i^{MEU}} \quad i \in S$$

(29)

$$P_i^{MCEE} = \left(1 + tm_i^{CEE}\right)P^{FE}\,\overline{WP_i^{MCEE}} \quad i \in S$$

(30)

$$P_i^{MBG} = \left(1 + tm_i^{BG}\right) P^{FE}\, \overline{WP_i^{MBG}} \qquad i \in S$$

(31)

$$P_i^{MRW} = \left(1 + tm_i^{RW}\right) P^{FE}\, \overline{WP_i^{MRW}} \qquad i \in S$$

(32)

where the left hand side variables are domestic export and import prices; the far right hand side variables are exogenous world export and import prices (which are equal in the benchmark); tm_i^{EU}, tm_i^{CEE}, tm_i^{BG}, and tm_i^{RW} represent the import tariff rates applied by Romania that are the same across trading regions in the benchmark. To note that although Bulgaria is a small open economy, it is assumed here that Romania will face fixed export and import prices from this country. This is due to the likely integration of Bulgaria into EU structures at the same time with Romania when domestic importers and exporters will then face given EU prices.

Net supply of exports is then equated to the value of foreign savings plus any exogenous level of transfers from abroad. This is the balance of payments equation in foreign terms that represents a further constraint on the model:

$$\overline{TR^{FH}} + \sum_{r \in R} \overline{SV_r^F} = \sum_{i \in S} \left(\overline{WP_i^{XEU}} XEU_i + \overline{WP_i^{XCEE}} XCEE_i + \overline{WP_i^{XBG}} XBG_i + \overline{WP_i^{XRW}} XRW_i \right) -$$
$$\sum_{i \in S} \left(\overline{WP_i^{MEU}} QM_i^{EU} + \overline{WP_i^{MCEE}} QM_i^{CEE} + \overline{WP_i^{MBG}} QM_i^{BG} + \overline{WP_i^{MRW}} QM_i^{RW} \right)$$

(33)

where $\overline{TR^{FH}}$ are transfers from foreigners to households that are assumed exogenous; and $\sum_{r \in R} \overline{SV_r^F}$ represents the value of (net) foreign savings summed over trading regions *r∈{EU,CEE, BG, RW}*. The right-hand side of the above equation represents the trade balance in foreign terms (hence QM_i^{EU}, QM_i^{CEE}, QM_i^{BG} and QM_i^{RW} represent the supply of imports coming from each region). This is fixed for model closure purposes. In other words, the modeller assumes that changes in global markets will dictate what will happen to the current account, thus exogenously fixing the trade balance (Hertel, 1999). It implies that the foreign value of exports can only change if matched by changes in the foreign value of imports and that the exchange rate adjusts to enable the government to move towards the assumed balance target. In addition, because the trade balance is equal to net foreign investments, any change in investment has to be financed from national savings in order to meet the fixed trade balance. The rule that investments are endogenous and adjust to accommodate changes in savings represents a further closure rule of a macroeconomic neo-classical nature that deals with the fundamental indeterminacy of investments in a comparative static model.[22]

Private consumption

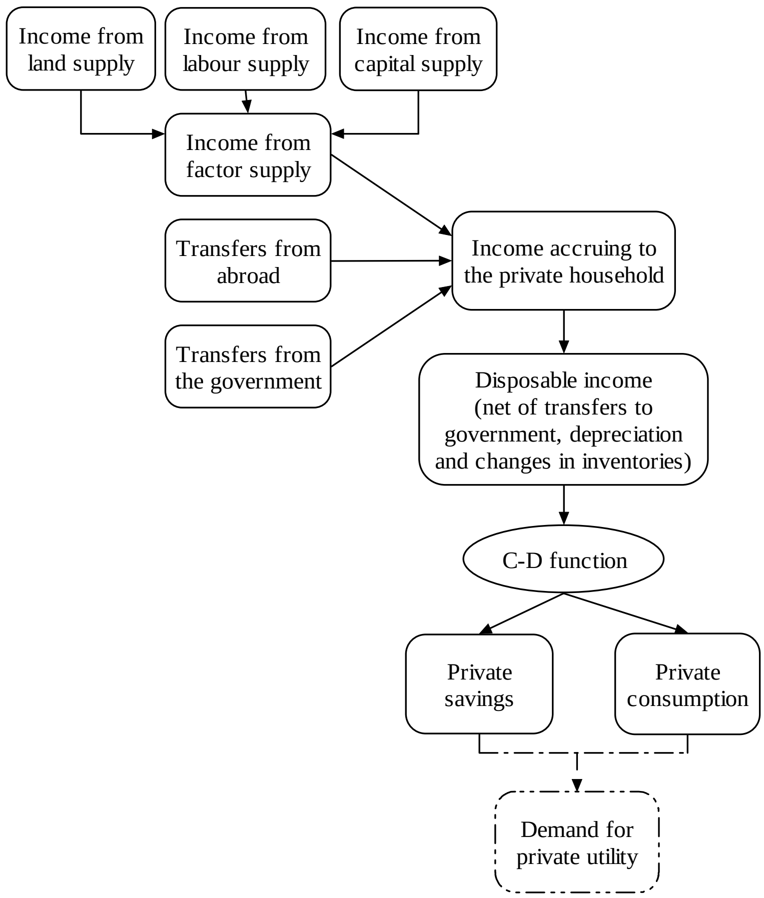
The private household receives income from its supply of factors of production, from transfers from abroad and from the government (see Figure 5).

$$Y = LDr_{LD} + Lw + Kr_k + \overline{TR^{FH}} P^{FE} + TR^{GH}$$

(34)

where Y is total income accruing to the household; LD, L, and K represent the employment of land, labour and, capital; $\overline{TR^{FH}}$ is a fixed transfer from abroad to the household; and TR^{GH} is the value of transfers from the government to the household. The latter is discussed in the following section on government consumption. There are no taxes applied on factors of production. However, there is a lump sum transfer from the household to the government that reflects direct taxes and are modelled below as a demanded good.

Figure 5: The private household



Source: Own diagram

The representative household maximises utility given by a Cobb Douglas function having as parameters pivate consumption and private savings (investment):

$$U = \left(QC^{P}\right)^{\gamma}\left(SV^{P}\right)^{1-\gamma}$$

(35)

where U is private utility; QC^P and SV^P represent the demands for private consumption and private savings; and parameters γ and $1\text{-}\gamma$ are calibrated expenditure shares of private consumption and private savings. The budget constraint that accounts for transfers to government, depreciation and any changes in inventories is as follows:

$$Y = P^{PC}QC^{P} + P^{I}SV^{P} - P^{I}\overline{DEP} + \sum_{i\in S} P_i\overline{CI_i} + TR^{HG} \qquad (36)$$

where P^{PC} and P^{I} are aggregated prices of private consumption and investment (explained in more detail below); $\overline{DEP}$ and $\overline{CI_i}$ are depreciation and changes in inventories in the benchmark dataset that are held fixed; TR^{HG} are transfers from households to government and represent a constant proportion of household income ($TR^{HG} = \eta Y$, where η is a calibrated share parameter). Maximisation of the above utility when all income is spent leads to the following expenditure equations:

$$QC^P = \frac{\gamma Y^D}{P^{PC}}$$

(37)

$$SV^P = \frac{(1-\gamma)Y^D}{P^I}$$

(38)

where Y^D is disposable income that is equal to total income net of transfers to the government, depreciation and changes in inventories.

A composite price index for consumption is represented as the dual price index of utility (P^U).

$$P^U = \left(P^{PC}\right)^{\gamma}\left(P^I\right)^{1-\gamma}$$

(39)

Furthermore, private consumption bundles together demands for each composite commodity *i* (C_i^P) according to a Cobb-Douglas production function:

$$QC^P = \Omega \prod_{i \in S} \left(C_i^P\right)^{\phi_i}$$

where Ω is a calibrated shift coefficient and ϕ_i represent calibrated share coefficients such that $\sum_{i \in S} \phi_i = 1$. In other words, private consumption can be viewed as a non-productive activity that bundles imported and domestic goods in a similar manner to production activities, except that they do not consume value added and the top-level nest is Cobb-Douglas rather than Leontief. The constraint is that the total value of private consumption equals the sum of consumption values of each composite good *i*:

$$QC^P P^{PC} = \sum_{i \in S} P_i C_i^P$$

where P^{PC} was defined above as being the aggregate price of private consumption, and P_i is the main Armington price defined above as well in the aggregate demand section.

The optimising behaviour hence results in the following price and demand equations:

$$P^{PC} = \frac{1}{\Omega}\prod_{i\in S}(P_i)^{\phi_i} \qquad (40)$$

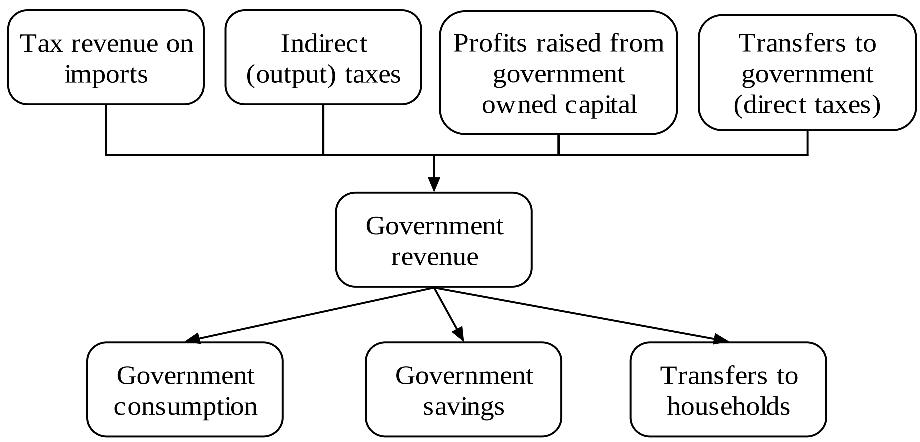
$$C_i^P = \phi_i QC^P \frac{P^{PC}}{P_i} \qquad i\in S$$

(41)

Government consumption

The government gains its revenue (*R*) from applying taxes (import tariffs, tm_i, and production taxes, tp_i), from transfers from households (TR^{HG}), and from the profits raised from government owned capital (r_{GK} rental price of government capital times the fixed quantity of government capital $\overline{GK_i}$) (see Figure 6). The latter represents an element specific to a transition economy like Romania where privatisation has not yet completed and the government still owns a significant amount of capital/enterprises.

Figure 6: Government consumption



Source: Own diagram

$$R = \sum_{i\in S}\begin{pmatrix} tm_i^{EU} PM_i^{EU} MEU_i + tm_i^{CEE} PM_i^{CEE} MCEE_i + \\ tm_i^{BG} PM_i^{BG} MBG_i + tm_i^{RW} PM_i^{RW} MRW_i + tp_i P_i^{AL} AL_i \end{pmatrix} + \sum_{i\in S} r_i^{GK}\overline{GK_i} + TR^{HG}$$

(42)

Hence, the revenue raised by the government is spent on consumption (public expenditures), investments (savings), and the residual is transferred to households (in a lump-sum manner). Any positive government savings reflect a budget surplus, whilst any negative government savings indicate the existence of a budget deficit (the latter being the case of Romania for which the SAM displays minus 13250 billion lei in 1997 prices of government savings). No export subsidies are initially assumed. For government closure purposes and for welfare implications that consider only private gains accruing to consumers and producers (i.e. private welfare effect), government (public) expenditures are held fixed. Any change in real government revenue is matched by a proportionate increase in transfers to households in order to achieve fiscal neutrality so that government consumption is unchanged, allowing the use of private utility as a proxy for social welfare. This also implies that the budget deficit (government negative savings in this case) is held fixed.

Government transfers to the representative household are computed as the difference between government revenue and government spending on consumption and investment goods evaluated at aggregated Armington prices:

$$TR^{GH} = R - \sum_{i \in S} P_i \overline{C_i^G} - P^I \overline{SV^G}$$

(43)

Where P_i was the aggregate Armington price; P^I represented the price of investment; $\overline{C_i^G}$ and $\overline{SV^G}$ are real government consumption associated with each product, and respectively, real government savings, both being held constant in the model.

Foreign savings

Foreign savings from each trading region appear as well in the SAM and are also modelled as a consumer that is endowed with resources in terms of foreign prices and consumes savings in Romania:

$$R_r^{FI} = P^{FE} \overline{SV_r^F} \qquad r \in \{EU, CEE, BG, RW\}$$

(44...47)

where R_r^{FI} is the revenue associated with economic agents from region *r* saving in Romania, whilst the right hand term represents expenditures on the domestic value of net foreign savings associated with each trading region.

Investments

Total investments (QI) net of depreciation are financed from private savings, government savings and foreign savings. In other words, the supply of loanable funds equates the demand for loanable funds, and the savings-investments market clearance condition expressed in real terms is formulated as follows:

$$QI = SV^P + \overline{SV^G} + \sum_r \overline{SV_r^F} \frac{P^{FE}}{P^I} + \overline{DEP} \qquad r \in \{EU, CEE, BG, RW\}$$

(48)

In addition, total investments bundle together investment demands for each composite commodity *i* (I_i) according to a Cobb-Douglas production function:

$$QI = \Lambda \prod_{i \in S} (I_i)^{\pi_i}$$

where Λ is a calibrated shift coefficient and π_i represent calibrated share coefficients such that $\sum_{i \in S} \pi_i = 1$. In other words, investments as private consumption may be considered as a non-productive activity that bundles imported and domestic goods in a similar manner to production activities, except that they do not consume value added and the top-level nest is Cobb-Douglas rather than Leontief. The constraint is that the total value of investment equals the sum of investment values over each composite good *i*:

$P^I QI = \sum_{i \in S} P_i I_i$, where P^I was defined above as being the aggregate price of investment, and P_i is the main Armington price. The optimising behaviour hence results in the following price and demand equations:

$$P^I = \frac{1}{\Lambda} \prod_{i \in S} (P_i)^{\pi_i} \qquad (49)$$

$$I_i = \pi_i QI \frac{P^I}{P_i} \qquad i \in S$$

(50)

Factor and commodity markets

An essential condition in general equilibrium models is that factor and commodity markets clear. This would translate into total factor employment equalling the sum of factor demand over sectors for each factor of production employed:

$$LD = \sum_{i \in S} QLD_i \qquad (51)$$

$$L = \sum_{i \in S} QL_i \qquad (52)$$

$$K = \sum_{i \in S} QK_i \qquad (53)$$

$$\overline{GK_i} = QGK_i \qquad i \in S$$

(54)

where *LD*, *L*, *K* and $\overline{GK_i}$ are total employment of land, labour, private capital, and respectively, government owned (fixed) sector specific capital; QLD_i, QL_i, QK_i and QGK_i are factor demands in sector *i*. Thus, the first three equations relate to factors that are fully mobile across sectors, whereas the latter is associated with sector specific capital that is owned by the government. However, factor employment is not equivalent to factor supply as the model takes into account factor unemployment. Or put differently, supplies of labour, capital and land are endogenised in the model, and factor markets are closed by changes in factor unemployment levels. The following equations describe the employment conditions for each factor of production that are assumed to follow a Phillips curve. Thus, unemployment (*U*) is inversely related to real returns to the respective factors, *e.g.* an increase in real wages is associated with a decrease in unemployment: $U_L = U_L^O \left(\frac{w}{P^U} \right)^{\Phi_L}$, where U_L^O is the level of unemployment in the reference year; $\left(\frac{w}{P^U} \right)$ is real return to labour; and Φ_L represents the unemployment elasticity with respect to pay. Replacing unemployment level by the unemployment rate multiplied by the level of labour supply we obtain: $u_L = u_L^0 \left(\frac{w}{P^U} \right)^{\Phi_L}$, where u_L^O is the benchmark unemployment rate. Similar relationships characterise the land and capital factors. Hence, the employment conditions for the factors of production are:

$$\frac{LD}{LD^O} = \frac{1 - u_{LD}^0 \left(\frac{r_{LD}}{P^U} \right)^{\Phi_{LD}}}{1 - u_{LD}^0}$$

(55)

$$\frac{L}{L^O} = \frac{1 - u_L^0 \left(\frac{w}{P^U} \right)^{\Phi_L}}{1 - u_L^0}$$

(56)

$$\frac{K}{K^O} = \frac{1 - u_K^0 \left(\frac{r_K}{P^U} \right)^{\Phi_K}}{1 - u_K^0}$$

(57)

where LD^O, L^O, and K^O are factor employment in the benchmark year; u_{LD}^0, u_L^0, and u_K^0 are initial given unemployment rates associated with each factor (that are assumed to equal to the value of unemployment rate of labour force in the benchmark dataset due to data unavailability);[23] Φ_{LD}, Φ_L, and Φ_K are as mentioned above unemployment elasticities of each factor of production with respect to its associated real return (that again are equal to the value of elasticity of unemployment with respect to pay in the benchmark dataset due to data unavailability).[24] The model assumes no changes in the employment of sector specific government owned capital: $\overline{GK_i} = GK_i^0$ ($i \in S$).

As to what regards commodity markets, the model refers to two main types: a market for goods domestically produced, and a market for goods imported from abroad:

$$QD_i = DD_i \qquad i \in S$$

(58)

$$QM_i = M_i \qquad i \in S$$

(59)

where the supply of domestically produced good (QD_i) and imports (QM_i) equals demand for domestically produced goods, and respectively, for imported commodities. The market for imported goods imported is in its turn split into four markets associated with each trading region:

$$QM_i^{EU} = MEU_i \qquad i \in S$$

(60)

$$QM_i^{CEE} = MCEE_i \qquad i \in S$$

(61)

$$QM_i^{BG} = MBG_i \qquad i \in S$$

(62)

$QM_i^{RW} = MRW_i$ $\qquad i \in S$

(63)

And finally, we have the demand equation that equals total domestic demand (AD_i) with the sum of demand for intermediate goods ($\sum_j QII_{j,i}$), private consumption (C_i^P), investment (I_i), government consumption ($\overline{C_i^G}$), and changes in inventories ($\overline{CI_i}$):

$AD_i = \sum_j QII_{j,i} + C_i^P + I_i + \overline{C_i^G} + \overline{CI_i}$ $\qquad i, j \in S$

(64)

Thus, the 64 equations presented above fully define the model. Taking into account the 23 sectors/commodities considered in this model, we consequently have a square system of 1493 equations and 1493 endogenous variables that fully define the AGE model (a list of endogenous variables, exogenous variables, and model parameters are provided in the appendix in box A1).[25] Once the model is correctly specified, the model solver computes an equilibrium solution for the benchmark year. This is given by a set of equilibrium quantities, prices, and incomes from all sources such that all markets clear.

AN EXAMPLE USING GEMAR: TWO UNILATERAL TRADE LIBERALISATION SCENARIOS

This section presents a simple simulation example using GEMAR, the twenty-three sector single-country static applied general equilibrium model described above. It succinctly displays potential changes in output and trade patterns, as well as welfare impacts associated with two unilateral trade liberalisation scenarios. These simulations are only for illustrative purposes and are not intended to accurately represent possible policy changes:

(i) Simulation 1: the abolition by Romania of tariffs on all import flows from the enlarged EU26,[26] and
(ii) Simulation 2: a complete elimination by Romania of all import tariffs from all trading regions.

The average import tariffs applied by Romania in the 1997 benchmark year are derived by taking the ratio of total tariff revenue to total imports for each of the twenty-three aggregated groups of commodities (see table A5 in the appendix for a list of computed import tariff rates). The resulting tariff rates reflect the level of border protection as of 1997 that was higher for agro-food products and lower for other goods, the liberalisation of trade in the latter experiencing more substantial progress, in particular with respect to EU and CEFTA countries.[27] The simulations involve setting the corresponding tariffs to zero, and thus reflect alternative liberalisation scenarios relative to the 1997 benchmark year.

The predicted changes in output and trade patterns, and estimated welfare effects associated with the two unilateral trade liberalisation scenarios are displayed in Table 1.[28] The simulations have been carried out first with respect to imports of all goods from EU26 countries and second with respect to imports of all goods from all countries. Changes relative to the benchmark have been reported in both percentage and absolute terms. Deviations from the baseline in percentage terms are usually referred to in the modelling literature, as these tend to reflect the importance of such changes. However, absolute changes (in terms of 1997 constant billion ROL) are also relevant as they render a description of the magnitude of the respective impact, *i.e.* how large is the change in the volume of production and trade associated with each sector. In other words, a sector might experience a significant output change in percentage terms but a less significant alteration in its production volume, if the initial (benchmark) importance of the respective sector in total output is relatively low.

Economic intuition tells us that if tariffs are unilaterally and preferentially removed on imports from a partner country then imports with that partner country increase and replace to a certain extent imports with other trading partners. Domestic import-competing industries face fiercer competition from cheaper imports, inducing domestic producers to shift their resources towards export-oriented production activities.

Table 1 The impact of a preferential, and respectively, full liberalisation on output and trade

- percentage (absolute) changes relative to the benchmark –

		Unilateral trade liberalisation with respect to EU26 countries - Simulation 1 -					Unilateral trade liberalisation with respect to ALL countries - Simulation 2 -				
		AL	XEU26	XRW	MEU26	MRW	AL	XEU26	XRW	MEU26	MRW
Agriculture	Wheat	-2.4 (-279.4)	7.8 (2.7)	7.8 (29.0)	1036.1 (260.7)	- -	-2.1 (-242.5)	14.9 (5.1)	14.9 (55.2)	967.9 (243.5)	- -
	Other cereal grains	-1.9 (-200.9)	8.2 (8.0)	8.2 (30.1)	436.5 (231.1)	-62.9 (-56.3)	-3.4 (-365.5)	13.2 (12.8)	13.2 (48.1)	208.5 (110.4)	208.5 (186.5)
	Vegetables, fruit, nuts	-0.9 (-77.5)	6.6 (7.9)	6.6 (6.0)	161.1 (98.0)	-29.8 (-47.1)	-2.3 (-200.6)	10 (12.0)	10 (9.1)	66.3 (40.3)	66.3 (104.8)
	Oil seeds	-2.9 (-37.0)	6.8 (4.6)	6.8 (1.4)	577.3 (74.8)	-46.4 (-32.1)	-11.7 (-149.8)	3.1 (2.1)	3.1 (0.7)	162 (21.0)	162 (112.2)
	Sugar cane, sugar beet	-0.6 (-6.8)	Not externally traded				-4.9 (-53.2)	Not externally traded			
	Plant-based fibers	-5.4 (-33.6)	2.4 (0.3)	2.4 (0.1)	169.8 (161.4)	-32.4 (-101.4)	-20.9 (-129.6)	-8.2 (-0.9)	-8.2 (-0.3)	35.2 (33.5)	35.2 (110.3)
	Other crops	-2.1 (-167.8)	5.6 (2.3)	5.6 (0.5)	132.7 (163.6)	-38.7 (-59.6)	-3.3 (-267.0)	10.1 (4.1)	10.1 (0.8)	65.2 (80.4)	65.2 (100.5)
	Cattle, sheep & goats, horses	-0.5 (-27.6)	6 (10.9)	6 (17.4)	315.7 (70.8)	-75.6 (-2.9)	-0.1 (-0.8)	10.9 (19.8)	10.9 (31.5)	265.3 (59.5)	265.3 (10.3)
	Other animal products	0.1 (22.3)	7.1 (15.8)	7.1 (2.8)	151.1 (39.7)	-24.4 (-19.7)	0.1 (7.9)	11.7 (26.1)	11.7 (4.6)	62.8 (16.5)	62.8 (50.7)
	Raw milk	-1.6 (-206.3)	3.4 (0.5)	3.4 (0.0)	315.7 (45.7)	-76.8 (-1.0)	-1.4 (-182.1)	6.9 (1.0)	6.9 (0.0)	285.1 (41.2)	285.1 (3.6)
	Wool, silk-worm cocoons	-3.9 (-33.9)	0.3 (0.0)	0.3 (0.1)	396 (47.5)	-46.4 (-14.6)	-9.5 (-82.2)	-2.4 (-0.1)	-2.4 (-0.9)	153 (18.4)	153 (48.3)
Food processing	Bovine, sheep, goats & horse meat	-2.1 (-117.2)	-1 (-0.8)	-1 (-1.8)	236.7 (99.6)	-24.7 (-39.0)	-4.8 (-268.8)	-2.5 (-2.1)	-2.5 (-4.5)	95.8 (40.3)	95.8 (151.4)
	Other meat products	-4.1 (-327.6)	-3.1 (-6.5)	-3.1 (-5.8)	100.8 (265.3)	-51.1 (-14.6)	-4.7 (-383.3)	-2.7 (-5.5)	-2.7 (-4.9)	88.5 (232.9)	88.5 (25.3)
	Vegetable oils & fats	-6.8 (-235.6)	-3.9 (-4.4)	-3.9 (-23.6)	94.7 (228.2)	-47.7 (-47.3)	-8.2 (-285.0)	-2.6 (-2.9)	-2.6 (-15.5)	61.6 (148.6)	61.6 (61.1)
	Dairy products	-12.3 (-767.6)	-8.8 (-2.7)	-8.8 (-0.6)	456.2 (663.1)	-86 (-11.2)	-12.9 (-802.9)	-7.3 (-2.3)	-7.3 (-0.5)	415.9 (604.7)	415.9 (54.3)
	Sugar	-2.2 (-98.3)	2 (0.6)	2 (0.2)	447.6 (151.9)	-15.2 (-109.1)	-18.2 (-803.8)	-10 (-3.3)	-10 (-0.8)	88.8 (30.1)	88.8 (637.1)
	Other food products	-5.1 (-1032.0)	-1.1 (-3.0)	-1.1 (-1.6)	131.4 (1309.1)	-38.2 (-477.3)	-9.3 (-1899.6)	-1.6 (-4.3)	-1.6 (-2.4)	61.1 (608.5)	61.1 (763.3)
	Beverages & tobacco products	-2.9 (-618.0)	-2 (-1.8)	-2 (-6.6)	177.5 (534.7)	-34.3 (-170.1)	-5.3 (-1124.0)	-2.2 (-2.0)	-2.2 (-7.1)	88.3 (265.9)	88.3 (438.2)
	Other primary products	0.2 (44.9)	1.2 (1.7)	1.2 (1.4)	9.3 (28.4)	-0.9 (-141.2)	-0.8 (-167.0)	2.1 (2.8)	2.1 (2.3)	1.3 (3.9)	1.3 (190.2)
Manufactures	Textiles, wearing apparel & leather	28.2 (6713.2)	34.3 (4744.0)	34.3 (753.4)	12.6 (1658.9)	-11.5 (-164.9)	41.2 (9819.3)	49.7 (6880.4)	49.7 (1092.6)	13.7 (1806.9)	13.7 (195.8)
	Machinery, equipment & transport means	-1.0 (-397.7)	0.8 (33.3)	0.8 (29.4)	10.1 (1475.4)	-10.1 (-757.6)	-0.9 (-340.6)	2.4 (105.0)	2.4 (92.6)	4.3 (626.6)	4.3 (321.8)
	Other manufacturing	-0.3 (-297.0)	1.7 (248.8)	1.7 (247.5)	14.6 (2092.8)	-10.2 (-1246.4)	0.4 (450.6)	4.8 (703.0)	4.8 (699.4)	4.9 (710.6)	4.9 (603.3)
	Services	-0.3 (-691.4)	0.1 (8.4)	0.1 (5.3)	0 (-0.4)	-1.2 (-32.0)	-0.4 (-743.1)	1 (55.7)	1 (34.9)	-1.2 (-37.7)	-1.2 (-33.8)

Source: Own AGE modelling results

Notes: Absolute changes in terms of constant 1997 billion ROL are displayed in brackets. The percentage (absolute) changes in Romanian trade with EU15, CEEC10 and BG have been aggregated into a single column labelled EU26. AL stands for activity level (output), XEU26 and XRW are exports to EU26 countries and to the rest of the world, MEU26 and MRW are imports from EU26 countries and from the rest of the world.

Nonetheless, it is difficult to theoretically predict within a general equilibrium context the likely resource re-allocation effects across several domestic production activities stemming from import tariff removal and cheaper import inflows. The numerical AGE model employed here is capable, using a sound theoretical framework, of overcoming such ambiguities and indicating likely changes that one can reasonably expect.

A unilateral trade liberalisation translates into cheaper import prices and an increase in the quantity of imports from countries that gain greater access to Romanian markets. Thus, the first simulation predicts significant growth in imports from EU26 and a fall in import flows from other countries, whilst the second scenario estimates import growth from all trading partners. In both cases, the magnitude of changes in import patterns across sectors and regions depends on a combination of three factors: the assumed tariff cut (that feeds into import prices), Armington elasticity of substitution values, and the calibrated share coefficients associated with aggregate demand and import demands (see tables A3, A4 and A6 in the appendix for actual values) that give rise to equations (17) to (24). In other words, the higher the shock to the system or the larger the tariff cut the bigger the impact on changes in import intensities. Furthermore, the higher the Armington elasticity the more homogeneous foreign and domestic products and the more substantial is the resulting increase in imports. And finally, the bigger the share of imports in domestic demand or the larger the share of imports for a specific region in total imports the higher the increase in corresponding import inflows. However, the assumed tariff cut and in particular the Armington elasticity seem to have a greater impact than the respective share coefficients on changes in import demands. Hence, GEMAR indicates a large increase in imports of agricultural and food products in both simulation scenarios. This is because these commodities experience not only the largest tariff cuts but also high Armington elasticity values relative to those associated with manufactures or services. For instance, imports of wheat from EU26 are predicted to grow the most in terms of percentage changes due to a high initial import tariff rate of around 70 percent and a high elasticity value of 5. Nevertheless, in terms of absolute changes, the volume of imports from EU26 member states increases the most for manufacturing products (due to their prevalence and high share in total imports).

A theoretical two-good general equilibrium model would predict that unilateral trade liberalisation leads to an expansion of export-oriented activities and a contraction of import-competing sectors. However, when several industries that simultaneously supply domestic and export markets are included in a model characterised by a given set of factor endowments, not all sectors will be able to expand their exports. Some activities witness a contraction in their exports as resources flow into other more promising sectors. The net effect on output across sectors is theoretically ambiguous and depends amongst many other factors on the share of exports in total output associated with each activity.[29] Applied general equilibrium modelling and in this case GEMAR is able to solve for such ambiguities and to indicate likely directions of change for each sectoral output and exports. The results reveal a contraction in all sectors in both scenarios with the exception of the textiles, wearing apparel and leather (*twl*) sector. Due to this sector's high share of exports in production (almost 70 percent of production was exported in 1997), the *twl* activity is able to attract resources away from other sectors and considerably expand exports and total output. Hence, output and exports associated with textile, wearing apparel and leather grow the most in both liberalisation scenarios in terms of both percentage and absolute changes relative to the benchmark year. For instance, exports for *twl* are predicted to grow by 30 and 50 percent, whilst production is estimated to increase by roughly 30 percent and 40 percent, corresponding to the first, and respectively, the second simulation scenario. Agricultural and food producers slightly increase their exports. Nonetheless, due to the low share of exports in production associated with these sectors (see table A6), exports do not expand sufficiently for total agro-food output to rise. Moreover, although sugar beet is not externally traded and one would expect that resources freed from import-competing sectors would also flow into non-tradables, its output declines in both liberalisation scenarios. This is because sugar beet is a major intermediary input into the production of (refined) sugar, and a drop in sugar output tends to be associated with a drop in the demand and the cultivation of sugar beet. Consequently, agro-food producers are likely to get hurt by the surge in imports and the increase in the consumption of foreign goods induced by the respective tariff removals. The change in production and export patterns are also influenced by the constant elasticity of transformation (CET) between exported and domestically targeted products (see the output transformation function and equation 11 in the previous section). In other words the higher the CET the less differentiated are products across targeted markets and the easier it is for producing units to shift towards exporting activities.

With respect to the first simulation, in terms of welfare impacts the preferential unilateral trade liberalisation might induce both trade creating and trade diverting effects. In a

Vinerian sense, regional integration reflected by the removal of import tariffs "creates" trade when more expensive domestic production is substituted by cheaper products from bloc members, and "diverts" trade when cheaper imports from outside the union are substituted by more expensive intra-bloc imports (assuming that both initially faced equal tariffs) (Schiff and Winters, 2003). In addition, trade diversion might not only induce extra inefficiencies but also generate significant government revenue losses with negative repercussions for private welfare. This is due to both the elimination of duties on imports from member countries and the reduction in tariff revenue collected on imports from non-member countries. Hence, from a theoretical standpoint a preferential unilateral liberalisation can result in either positive or negative welfare gains (see box A2 in the appendix for a succinct theoretical presentation of welfare effects from a partial equilibrium perspective). Yet again, the AGE model helps to clarify the respective ambiguous theoretical outcome. However, this is not accomplished through the abstract summation of producer, consumer and taxpayer surplus mostly valid within partial equilibrium set-ups, but by computing welfare effects directly through changes in household utility. After all, the representative modelled household embodies all three elements of income generation, consumer expenditure and the payment of taxes or the receipt of subsidies (Hertel, 1999). Thus, the model predicts for a preferential unilateral trade liberalisation small welfare gains in terms of equivalent variation as a percentage of GDP of only 0.07 corresponding to an increase of 168.1 billion ROL (table 2).[30]

Table 2 The impact of a preferential, and respectively, full liberalisation on private economic welfare

	Unilateral trade liberalisation with respect to EU26 countries - Simulation 1 -	Unilateral trade liberalisation with respect to ALL countries - Simulation 2 -
EV as % of GDP	0.07	0.23
EV (1997 constant billion ROL relative to the benchmark)	168.1	529.2

Source: Own AGE modelling results

Notes: EV is the equivalent variation expressed as a percentage of GDP. EV is a measure of private economic welfare that represents the change in the original amount of income that would generate the same level of household utility as that obtained in the new equilibrium.

In other words, it seems that in this case trade creation effects are almost cancelled out by trade diversion effects.[31] However, if Romania were to eliminate tariffs on all imports from all regions, welfare gains are estimated to increase to 0.23 percent of GDP equivalent variation corresponding to an increase of 529.2 billion ROL. Thus, welfare gains could be attributed to two main driving forces. On one hand, there is a more efficient reallocation of real resources by shifting production in the direction of comparative advantage and allowing foreign industries to displace higher-cost domestic production. On the other hand, cheaper imports translates into an increase in import inflows, a rise in domestic consumer choice, and improved opportunities for domestic producers to purchase cheaper foreign supplies for intermediate consumption purposes. Nevertheless, the magnitude of the change in welfare is still relatively small even when Romania liberalises its imports from all trading partners. This might be attributed not only to welfare losses in terms of foregone import-tariff revenue but also to the tariff protection patterns and macroeconomic structure of the economy in the benchmark equilibrium. Thus, border protection was not particularly high in 1997 (manufactures that have the highest share in trade displayed import tariff rates below ten percent) and consequently the removal of trade distortions does not bring substantial allocative efficiency gains as it would have been the case if tariff rates were much above benchmark levels. Welfare effects also depend on other distortions present in the economy, such as output taxes (see table A7 in the appendix). In other words, efficiency gains are not fully achieved if prices are not fully liberalised and other distortions eliminated from the economy. Finally, it is worth noting that the size of welfare effects is also dependent on the role of trade in the economy and on the product differentiation assumption. The greater is the weight of trade in the national economy the larger is the welfare impact. With reference to the product differentiation assumption, goods are not assumed to be homogeneous across suppliers but rather display different degrees of heterogeneity from sector to sector. If there is substantial overlap between bundles of goods (high first-tier CES values) that the home and trading partner countries produce before the abolition of import tariffs then there is considerable scope for resource reallocation and inter-industry and intra-industry trade creation (Södersten and Reed, 1994; Robson, 1998). However, it seems that if there is considerable overlap (high second-tier CES values) between goods originating from member trading partners and trading non-partners then trade diversion tends to be emphasised over trade creation as imports from non-members are replaced at a higher rate by imports from members. However, trade diversion effects in terms of increased inefficiencies do not occur when the country theoretically liberalises its imports from all sources. That is why the model predicts higher welfare gains in the second scenario as opposed to the first.

CONCLUDING REMARKS AND FURTHER RESEARCH

Applied general equilibrium modelling represents a theoretically sound and powerful tool for predicting likely impacts arising from future or hypothesised policy shocks. It entails the main advantage of considering the complex simultaneous linkages, interactions and feedback effects between various sectors, institutions and factor resources within an economy, as well as the inter- and intra-industry trade links with other economies across the globe. This paper has described the steps undertaken to construct a single-country comparative static general equilibrium model applied to Romania. The model is static with constant returns to scale and perfect competition in production. The analytical structure that theoretically underpins the model has been displayed in detail and a simple simulation example has been provided to show how the model actually performs. The model has been labelled GEMAR (General Equilibrium Model Applied to Romania) and the SAM that numerically underlines it places an emphasis on the agricultural and food processing activities. This is because the model will be subsequently employed for assessing the impacts on the Romanian economy arising from EU accession likely to occur in 2007. More specifically, GEMAR is constructed in order to partially address the "black-box" critique usually associated with GE modelling and identify through further studies those economic impacts stemming from incorporating Romania's agricultural and food sectors into EU's Common Agricultural Policy.

A study that employs GEMAR in a slightly different format is Scrieciu (2004). The author deploys a more simplified version of the respective model to assess the economic impacts from incorporating the agricultural and food sectors into EU's customs union. For example, it assumes full employment of resources and hence does not account for unemployment. Nevertheless, the analytical description of GEMAR presented in this paper should be seen as a conceptual and theoretical foundation of the methodology employed in Scrieciu (2004), though it comes at a relatively later stage in time. Further research that makes use of GEMAR is in progress. This will provide more complex simulation scenarios that would reflect as best as possible CAP elements likely to be introduced with EU accession. In other words, border protection, domestic market support, supply control management policies, as well as the newly introduced single-farm (decoupled) payment will be modelled and included in simulation scenarios. In addition, a baseline scenario will be constructed that allows for a more plausible situation of Romania's economy at the moment of accession. This would entail projected economic growth, a complete liberalisation of trade between EU26 countries and Romania, an update of Romania's MFN applied import tariff rates, and an adjustment of EU's *ad-valorem* import tariff equivalents and export subsidy rates according to Agenda 2000 and more recent 2003 CAP reforms. Other future research might further improve the model by updating the SAM that would reflect a more stable economy in transition or including dynamic aspects.

Although several other studies have employed general equilibrium modelling techniques to deal with EU enlargement issues, none of these have solely focused on the impact of extending the support provided under the CAP umbrella to Romanian agricultural producers. Therefore, the development of GEMAR with a focus on agricultural and food sectors intends to fill in a gap in the modelling literature dealing with further integration into EU and CAP structures. It also aims at tackling an issue that is currently of considerable interest for researchers and policymakers involved in agriculture and economic development in the context of EU's next phase of enlargement that is due to include *inter alia* Romania.

References

Acar, M. (1999) 'What is next for Turkey? Implications of Incorporating Agriculture into the Customs Union with the EU', GTAP resource no.194.

Banse, M. (2001) 'Study on the disaggregation of the GTAP database for the countries of Central and Eastern Europe', Final Report (ref.2000/S 136-088749), European Commission website.

Banse, M. (2003) 'CAP and EU Enlargement', paper presented at the USDA's Economic Research Service / Farm Foundation Conference on 'WTO: Competing Trade Policy Issues and Agendas', September 17, Washington, D.C.

Bayar, A., Cornelisse, P., Hoek van der, P., and C. Mohora (2004) 'Tax Harmonisation and Public Expenditures Restructuring in Romania, in the Process of Preparation for the EU Accession – A CGE Modelling Exercise', paper presented at the Conference *Input-Output and General Equilibrium. Data, Modeling, and Policy Analysis*, Brusels, September 2-4, 2004, organised by EcoMod Net and International Input-Output Association.

Blanchflower, D. (2001) 'Unemployment, well-being, and wage curves in Eastern and Central Europe', *Journal of the Japanese and International Economics*, Vol. 15, pp.364-402.

Brockmeier, M., Herok, A., von Ledebur, O. and P. Salamon (2003) 'EU Enlargement – A New Dimension', paper presented at the 25th Conference of the International Association of Agricultural Economists, August, 16-22, Durban (South Africa).

Ciupagea, C. (2001) 'The Hermin-LINK model for the Romanian economy', in Welfe (ed.) 2001, *Macromodels – Proceedings of the 27th International Conferences*, Dec 6-9, 2000, Zakopane, Poland.

Ciupagea, C., Marinas, L., Turlea, G., Unguru, M., Gheorghiu, R. and D. Jula (2004) 'A cost-benefit assessment of Romania's accession to European Union', Study no.12, Pre-accession Impact Studies II, European Institute of Romania, Bucharest.

Davies, J. (2004) 'Microsimulation, CGE and Macro Modelling for Transition and Developing Economies', Discussion Paper No. 2004/08, World Institute for Development Economics Research, United Nations University.

Dimaran, B.V., R.A. McDougall and T. Hertel (2002) 'V5 Documentation – Chapter 20: Behavioral parameters', GTAP resource no.783, Center for Global Trade Analysis, Purdue University.

Donnellan, T., Hanrahan, K., McQuinn, K. and B. Riordan (2002) 'Policy analysis with the AG-MEMOD model: dealing with diversity in the EU agri-food sector', paper for EAAE Congress 2002 (Zaragosa), Teagasc, Rural Economic Research Centre, Dublin.

Donnelly, W., Johnson, K. and M. Tsigas (2004) 'Revised Armington Elasticities of Substitution for the USITC Model and the Concordance for Constructing a Consistent

Set for the GTAP Model', Office of Economics Research Note No.2004-01-A, U.S. International Trade Commission.

EC (2002) 'Analysis of the Impact on Agricultural Markets and Incomes of EU Enlargement to the CEECs', European Commission (EC), Directorate General for Agriculture;

FAO (2003) 'WTO Agreement on Agriculture: The Implementation Experience – Developing Country Case Studies', Food and Agriculture Organisation (FAO), Rome.

Fuller, F., Beghin, J., Fabiosa, J., Mohanty, S., Fang, C., and P. Kaus (2002) 'Accession of the Czech Republic, Hungary and Poland to the European Union: Impacts on Agricultural Markets', *World Economy*, Vol. 25, No.3, pp.407-428.

Herok, C., and H. Lotze (2000) 'Implications of an EU Eastern Enlargement Under a New Common Agricultural Policy', *Journal of Policy Modelling*, Vol. 22, No. 6, pp.661-690.

Hertel, T. (1999) 'Applied General Equilibrium Analysis of Agricultural and Resource Policies', GTAP working paper no.03, Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University, W. Lafayette.

Jensen, H., Frandsen, S. and C. Bach (1998) 'Agricultural and Economy-Wide Effects of European Enlargement: Modelling the Common Agricultural Policy', Working Paper no.11/1998, Danish Institute of Agricultural and Fisheries Economics (SJFI);

Jensen, H. and S. Frandsen (2003) 'Implications of EU Accession of Ten New Members. The Copenhagen Agreement', Working Paper no.1/03, Danish Research Institute of Food Economics, Ministry of Food, Agriculture and Fisheries.

Johnson, H. (1960) 'The costs of protection and the scientific tariff', *Journal of Political Economy*, Vol. 68, pp.327-345.

Jomini, P., Zeitsch, J., McDougall R., Welsh A., Brow, S., Hambley, J. and J. Kelly (1991) 'SALTER: A General Equilibrium Model for the World Economy', volume 1: 'Model Structure, Database and Parameters', Australia Industry Commission, Canberra.

Kállai, E. and I. Traistaru (1998) 'Characteristics and Trends of Regional Labour Markets in Transition Economies: Empirical Evidence from Romania', LICOS Discussion paper, LICOS-Centre for Transition Economies, Katholieke Universiteit Leuven.

Kehoe, P. and T. Kehoe (1994) 'A Primer on Static Applied General Equilibrium Models'. *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol.18, no.1.

Kuhn, A., and P. Wehrheim (2002) 'Agricultural Trade Diversion due to EU Eastern Enlargement – A Quantitative Analysis based on a Partial Equilibrium World Trade Model (WATSIM)', GeWiSoLa 2002 in Halle/Saale, University of Halle-Wittenberg.

Lejour, A. M., de Mooij, R.A. and R. Nahuis (2001) 'EU enlargement: economic implications for countries and industries', The Hague, CPB Netherlands Bureau for Economic Policy Analysis.

Liapis, P. and M. Tsigas (1998) "CEEC Accession to the EU: A General Equilibrium Analysis", in Burfisher, M. and E. Jones (eds). "Regional Trade Agreements and U.S. Agriculture", USDA, ERS Agricultural Economics Report no.771, November, Washington DC;

Maliszewska, M. (2002) 'Eastern EU Expansion: Implications of the Enlarged Single Market for Current and New Member States', Sussex European Institute, University of Sussex.

Manoleli, D., Campeanu, V., Giurca, D. and L. Chivu (2004) 'Setting the Development Priorities for Romanian Agriculture and Rural Sector. The Impact of the New Common Agricultural Policy Reform', Study no.11, Pre-accession Impact Studies II, European Institute of Romania, Bucharest.

Mathiesen, L. (1985) 'Computation of Economic Equilibrium by a Sequence of Linear Complementarity Problems', *Mathematical Programming Study*, Vol. 23, pp.144-162.

Paltsev, S. (2004) 'Moving from Static to Dynamic General Equilibrium Economic Models (Notes for a beginner in MPSGE)', Technical Note No.4, Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Cambridge.

Perroni, C. and T. Rutherford (1998) 'A comparison of the performance of flexible functional forms for use in applied general equilibrium analysis', *Computational Economics*, Vol. 11, No. 3, pp.245-263.

Petersen, T. (1997) 'An introduction to CGE-modelling and an illustrative application to Eastern European Integration with the EU", Working Paper 4, Institute of Economics, University of Copenhagen.

Robinson, S., Cattaneo, A., and M. El-Said (2000) "Updating and estimating a Social Accounting Matrix Using Cross Entropy Methods", TMD Discussion Paper no.58, Trade and Macroeconomics Division, International Food Policy Research Institute, Washington D.C.

Robson, P. (1998) *The Economics of International Integration*, fourth edition, Routhledge.

Rutherford, T.F. (1999) 'Applied General Equilibrium Modeling with MPSGE as a GAMS Subsystem: An Overview of the Modeling Framework and Syntaxt', *Computational Economics*, Vol. 14, No. 1-2, pp.1-46.

Schiff, M. and L.A. Winters (2003) *Regional Integration and Development*, World Bank / OUP.

Scrieciu, S. (2004) 'Assessing the economic impacts of incorporating Romania's agricultural and food sectors into EU's customs union: an applied general equilibrium approach', *Romanian Journal of European Affairs*, Vol.4, No. 3, pp.57-76.

Shoven, J. and J. Whalley (1984) 'Applied general equilibrium models of taxation and international trade: an introduction and survey', *Journal of Economic Literature*, Vol. 22, No. 3, pp.1007-1051.

Söderstern, B. and G. Reed (1994) 'International Economics', third edition, MacMillian Press.

Thissen, M. (1998) 'A classification of empirical CGE modelling', SOM Research Report 99C01, University of Groningen, The Netherlands.

Vargas, E., Schreiner, D., Tembo, G., and D. Marcouiller (1999) 'Computable General Equilibrium Modeling for Regional Analysis', *The Web Book of Regional Science* (http://www.rri.wvu.edu/WebBook/Schreiner/contents.htm), Regional Research Institute, West Virginia University.

Wahl, O., Weber, G. and K. Frohberg (2000) 'Documentation of the Central and Eastern European Countries Agricultural Simulation Model (CEEC-ASIM Version 1.0)', Discussion Paper No. 27, Institute for Agricultural Development in Central and Eastern Europe (IAMO), Halle.

Walsh, P. and F. Duffy (2002) 'Individual Pay and Outside Options: Evidence from the Polish Labour Force Survey', CERT Discussion Paper No. 0201, Centre for Economic Reform and Transformation, Heriot Watt University.

APPENDIX

Table A1

The Social Accounting Matrix (SAM) format employed in GEMAR

	Expenditures								
				Institutions					
	Commodities (23)	**Activities (23)**	**Factors of production (3)**	**Private households**	**Government**	**Trading regions (4)**	**Savings - Investments**	**Changes in inventories**	**Total**
Receipts: Commodities (23)		Intermediate inputs		Private consumption	Government consumption	Exports	Investment demand for goods	Accumulation of inventories	**Demand**
Receipts: Activities (23)	Marketed outputs								**Gross output**
Receipts: Factors of production (3)		Gross value added							**Gross factor income**
Receipts: Institutions: Private households			Factor income to households		Transfers from government to households	Transfers from foreigners to households			**Household income**
Receipts: Institutions: Government	Tax revenue on imports	Indirect taxes on production (producer taxes)	Factor taxes	Transfers to government (direct taxes)					**Government income**
Receipts: Trading regions (4)	Imports								**Foreign exchange outflow**
Receipts: Savings - Investments			Depreciation	Household savings	Government savings	Foreign savings			**Savings**
Receipts: Changes in inventories							Change in inventories		**Reduction in inventories**
Total	**Supply**	**Activity expenditure**	**Factor expenditures**	**Household expenditures**	**Government expenditures**	**Foreign exchange inflow**	**Investment**	**Accumulation of inventories**	

Notes: An explanation of the receipts and expenditures is given in each cell for every account displayed in Figure A1 (the actual numbers that appear in each cell are available upon request from the authors). The numbers in parentheses show how many activities, commodities, and factors of production are employed in the model. Thus, there are 23 activities that produce 23 commodities by using land, labour and capital as primary factors of production. There are also 4 trading regions, the initial European Union members (EU15), the Central and Eastern European countries that recently joined EU15 (CEEC10), Bulgaria (BG), and the Rest of the World (RoW).

Table A2

Commodities / activities appearing in the SAM

No.	Code	Commodity / activity	No.	Code	Commodity / activity
1	WHT	Wheat	13	OMT	Other meat products
2	GRO	Other cereal grains	14	VOL	Vegetable oils and fats
3	V_F	Vegetables, fruit, nuts	15	MIL	Dairy products
4	OSD	Oil seeds	16	SGR	Sugar
5	C_B	Sugar cane, sugar beet	17	OFD	Other food products
6	PFB	Plant based fibers	18	B_T	Beverages and tobacco products
7	OCR	Other crops	19	OPP	Other primary products
8	CTL	Bovine cattle, sheep & goats, horses	20	TWL	Textiles, wearing apparel and leather
9	OAP	Other animal products	21	MET	Machinery, equipment & transport means
10	RMK	Raw milk	22	OMP	Other manufacturing products
11	WOL	Wool, silk-worm cocoons	23	SVC	Services
12	CMT	Bovine, sheep, goats & horse meat			

Source: Own analysis based on an aggregation of 56 sectors initially displayed in Banse (2001)

Table A3

Specification of CES (σ) values in value added

Code	σ	**Code**	σ
WHT	0.24	OMT	1.12
GRO	0.24	VOL	1.12
V_F	0.24	MIL	1.12
OSD	0.24	SGR	1.12
C_B	0.24	OFD	1.12
PFB	0.24	B_T	1.12
OCR	0.24	OPP	0.20
CTL	0.24	TWL	1.26
OAP	0.24	MET	1.26
RMK	0.24	OMP	1.26
WOL	0.24	SVC	1.39
CMT	1.12		

Source: Dimaran, B.V., R.A. McDougall and T. Hertel (2002), *V5 Documentation – Chapter 20: Behavioral parameters*, GTAP resource no.783, Center for Global Trade Analysis, Purdue University.

Table A 4

Specification of CES (ρ) and CET (θ) values

Code	ρ *and* θ	Code	ρ *and* θ
WHT	5.0	OMT	2.7
GRO	5.0	VOL	5.0
V_F	3.9	MIL	5.0
OSD	5.0	SGR	5.0
C_B	5.0	OFD	4.2
PFB	5.0	B_T	3.5
OCR	4.2	OPP	2.6
CTL	3.2	TWL	2.0
OAP	3.2	MET	2.3
RMK	2.5	OMP	2.9
WOL	2.5	SVC	2.1
CMT	2.7		

Source: Donnelly, W., K. Johnson, M. Tsigas and D. Ingersoll (2004), "Revised Armington elasticities of substitution for the USITC model and the concordance for constructing a consistent set for the GTAP model", Office of Economics Research Note n. 2004-01-A, U.S. International Trade Commission, Washington D.C.

Notes: The second tier CES and CET values are double the numbers specified above.

Table A5

Romanian MFN applied import tariff rates (*tm*) derived from the 1997 SAM

Code	*tm*	Code	*tm*
WHT	66.9%	OMT	29.9%
GRO	30.6%	VOL	14.0%
V_F	18.3%	MIL	44.6%
OSD	28.9%	SGR	20.5%
C_B	Not externally traded	OFD	17.0%
PFB	14.8%	B_T	22.8%
OCR	17.2%	OPP	1.9%
CTL	55.8%	TWL	6.2%
OAP	20.6%	MET	4.5%
RMK	78.1%	OMP	4.3%
WOL	56.0%	SVC	0.3%
CMT	32.0%		

Source: Own calculations based on the benchmark database

Notes: The figures reported above equally apply for all trading regions and are calculated for each commodity-group as a ratio between import tariff revenue and the value of total import inflows in 1997.

Table A6 The importance of each product / sector in trade and production

	Product shares in exports to EU26	Product shares in exports to RoW	Product shares in imports from EU26	Product shares in imports from RoW	Share (ε) of EU26 imports in total imports M^{EU26} / M
WHT	0.1%	1.4%	0.1%	0.0%	8.5%
GRO	0.2%	1.4%	0.1%	0.2%	21.0%
V_F	0.3%	0.3%	0.1%	0.4%	56.9%
OSD	0.2%	0.1%	0.0%	0.2%	76.4%
PFB	0.0%	0.0%	0.2%	0.7%	77.2%
OCR	0.1%	0.0%	0.3%	0.4%	83.0%
CTL	0.4%	1.1%	0.0%	0.0%	38.5%
OAP	0.6%	0.1%	0.1%	0.2%	85.1%
RMK	0.0%	0.0%	0.0%	0.0%	98.3%
WOL	0.0%	0.1%	0.0%	0.1%	7.9%
CMT	0.2%	0.7%	0.1%	0.4%	31.5%
OMT	0.5%	0.7%	0.5%	0.1%	52.6%
VOL	0.3%	2.2%	0.5%	0.2%	15.8%
MIL	0.1%	0.0%	0.3%	0.0%	82.0%
SGR	0.1%	0.0%	0.1%	1.7%	79.6%
OFD	0.7%	0.5%	2.1%	2.9%	64.5%
B_T	0.2%	1.2%	0.6%	1.2%	21.9%
OPP	0.3%	0.4%	0.6%	35.1%	54.6%
TWL	34.3%	8.1%	27.4%	3.4%	86.3%
MET	10.7%	14.1%	30.5%	17.7%	53.1%
OMP	36.3%	53.9%	29.9%	28.7%	50.1%
SVC	14.3%	13.4%	6.4%	6.5%	61.4%
	100.0%	100.0%	100.0%	100.0%	

	Share (ε) of RoW imports in total imports M^{RW} / M	Share (χ) of EU26 exports in total exports X^{EU26} / X	Share (χ) of RoW exports in total exports X^{RW} / X	Share (1-δ) of imports in domestic demand M / (AL-X+M)	Share (1-β) of exports in production X / AL
WHT	91.5%	8.5%	91.5%	0.2%	3.5%
GRO	79.0%	21.0%	79.0%	1.4%	4.3%
V_F	43.1%	56.9%	43.1%	2.5%	2.4%
OSD	23.6%	76.4%	23.6%	6.5%	7.0%
PFB	22.8%	77.2%	22.8%	40.2%	2.3%
OCR	17.0%	83.0%	17.0%	3.3%	0.6%
CTL	61.5%	38.5%	61.5%	0.5%	8.0%
OAP	14.9%	85.1%	14.9%	0.6%	1.5%
RMK	1.7%	98.3%	1.7%	0.1%	0.1%
WOL	92.1%	7.9%	92.1%	5.0%	5.0%
CMT	68.5%	31.5%	68.5%	3.6%	4.8%
OMT	47.4%	52.6%	47.4%	3.7%	4.8%
VOL	84.2%	15.8%	84.2%	11.0%	20.7%
MIL	18.0%	82.0%	18.0%	2.5%	0.6%
SGR	20.4%	79.6%	20.4%	14.6%	0.9%
OFD	35.5%	64.5%	35.5%	10.1%	2.0%
B_T	78.1%	21.9%	78.1%	3.7%	2.0%
OPP	45.4%	54.6%	45.4%	41.1%	1.1%

TWL	13.7%	86.3%	13.7%	65.2%	67.3%
MET	46.9%	53.1%	46.9%	41.7%	20.8%
OMP	49.9%	50.1%	49.9%	26.7%	28.5%
SVC	38.6%	61.4%	38.6%	2.9%	4.5%

Source: Own calculations based on the benchmark database

Note: The Greek symbols that appear in brackets correspond to the notation used in the mathematical formulations.

Table A7

Taxes on production (*tp*) derived from the 1997 SAM

Code	***tp***	**Code**	***tp***
WHT	-1.1%	OMT	1.1%
GRO	-2.3%	VOL	2.0%
V_F	-1.1%	MIL	1.4%
OSD	-2.2%	SGR	2.1%
C_B	-0.9%	OFD	1.3%
PFB	0.0%	B_T	0.9%
OCR	-0.2%	OPP	-0.9%
CTL	-0.7%	TWL	2.8%
OAP	-0.9%	MET	3.5%
RMK	-0.9%	OMP	1.6%
WOL	0.0%	SVC	3.5%
CMT	1.2%		

Source: Own calculations based on the benchmark database
Notes: A negative number means that sector was receiving output subsidies. The output tax rates are calculated as the ratio between production tax revenue and the marketed output associated with each sector.

Box A1: List of endogenous and exogenous variables and parameters employed in GEMAR

Endogenous variables:

AL_i	activity level of production associated with sector *i*
QVA_i	quantity of value added in sector *I*
$QII_{j,i}$	quantity of intermediate input of composite good *j* in sector *i*
QLD_i	demand for land associated with sector *i*
QL_i	demand for labour associated with sector *i*
QK_i	demand for private capital associated with sector *i*
QGK_i	demand for government capital associated with sector *i*
LD	total land employment
L	total labour employment
K	total private capital employment of private capital
QD_i	output of commodity *i* supplied to the domestic market
X_i	output of commodity *i* supplied to foreign markets (exports)
XEU_i	output of commodity *i* exported to EU15 member states
$XCEE_i$	output of commodity *i* exported to CEEC10 countries
XBG_i	output of commodity *i* exported to Bulgaria
XRW_i	output of commodity *i* exported to the rest of the world
AD_i	aggregate demand of commodity *i*
DD_i	demand for the domestically produced commodity *i*
M_i	total demand for imports of commodity *i*
QM_i	total supply of imports of commodity *I*
MEU_i	demands for imports of commodity *i* originating from EU15
$MCEE_i$	demands for imports of commodity *i* originating from CEEC10
MBG_i	demands for imports of commodity *i* originating from Bulgaria
MRW_i	demands for imports of commodity *i* originating from the rest of the world
QM_i^{EU}	supply of imports of commodity *i* originating from EU15
QM_i^{CEE}	supply of imports of commodity *i* originating from CEEC10
QM_i^{BG}	supply of imports of commodity *i* originating from Bulgaria
QM_i^{RW}	supply of imports of commodity *i* originating from the rest of the world
P_i^{AL}	producer price for commodity *i*
P_i^{VA}	price of value added associated with commodity *i*
r_{LD}	rate of return to land
w	wage rate accruing to labour
r_K	rate of return to private capital
r_i^{GK}	rate of return to government capital
P_i^D	price associated with output of commodity *i* sold on the domestic market
P_i^X	composite export price of commodity *i* sold on foreign markets

Box A1 continued

P_i^{XEU}	export price of commodity *i* sold in EU15
P_i^{XCEE}	export price of commodity *i* sold in CEEC10
P_i^{XBG}	export price of commodity *i* sold in Bulgaria
P_i^{XRW}	export price of commodity *i* sold in RoW
P_i	aggregate Armington price of commodity *i* (consumer price or main price)
P_i^{M}	composite import price of commodity *i*
P_i^{MEU}	import price (tarrif-inclusive) of commodity *i* originating from EU15
P_i^{MCEE}	import price (tarrif-inclusive) of commodity *i* originating from CEEC10
P_i^{MBG}	import price (tarrif-inclusive) of commodity *i* originating from Bulgaria
P_i^{MRW}	import price (tarrif-inclusive) of commodity *i* originating from RoW
Y	(representative) household income
TR^{GH}	value of transfers from the government to the household
TR^{HG}	value of transfers from the household to the government
U	private (household) utility
QC^{P}	total demand for private consumption
SV^{P}	total demand for private savings
P^{PC}	aggregate (private) consumption price
P^{I}	aggregate investment price
P^{U}	price of utility
C_i^{P}	demand for private consumption of composite commodity *i*
R	government revenue
R_r^{FI}	revenue associated with foreign savings from region *r* flowing into Romania
QI	total investments
I_i	investment demand for composite commodity *I*

List of exogenous variables:

P^{FE}	price of foreign exchange (chosen as *numeraire* in the modelling application)
WP_i^{X}	world price of exports that applies to all trading partners considered: $WP_i^{X} = WP_i^{XEU} = WP_i^{XCEE} = WP_i^{XBG} = WP_i^{XRW}$
WP_i^{M}	world price of imports that applied to all trading partners considered: $WP_i^{M} = WP_i^{MEU} = WP_i^{MCEE} = WP_i^{MBG} = WP_i^{MRW}$
TR^{FH}	benchmark transfers from foreigners to households
SV_r^{F}	benchmark value of foreign savings associated with each trading region *r*
DEP	benchmark depreciation value
CI_i	benchmark changes in inventories of commodity *i*
GK_i	quantity of sector *i* specific government capital
C_i^{G}	government consumption of commodity *i* (in real terms)
SV^{G}	total government savings (in real terms)

<u>Box A1</u> <u>continued</u>

List of parameters:

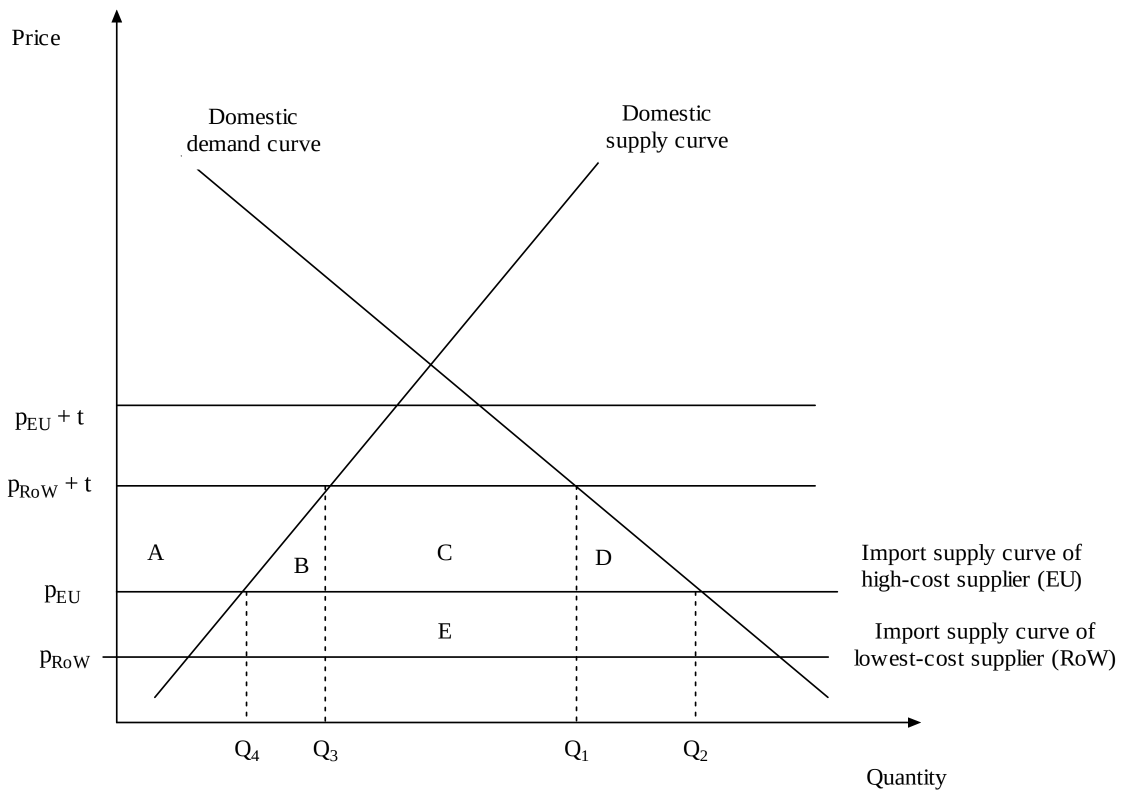
a_i^{QVA}	Leontief efficiency parameter of real value added in sector *i*
$a_{j,i}^{QII}$	Leontief efficiency parameter of intermediate input *j* in output *i*
a_i	shift coefficient associated with the CES function of value added in sector *i*
α_i^{QLD}	share coefficient of land in total value added in sector *i*
α_i^{QL}	share coefficient of labour in total value added in sector *i*
α_i^{QK}	share coefficient of private capital in total value added in sector *i*
α_i^{QGK}	share coefficient of government-owned capital in total value added in sector *i*
σ_i	constant elasticity of substitution between factors of production in sector *i*
tp_i	tax on production associated with sector *i*
b_i	shift coefficient associated with the output *i* transformation function
β_i^{QD}	share coefficient of supply to the domestic market in total supply of commodity *i* (1- β_i^{QD} represents hence the share of supply to foreign markets in total supply)
θ_i	constant elasticity of transformation associated with output *i* ($2\theta_i$ hence constitutes the constant elasticity of transformation that differentiates exports according to their destination)
c_i	shift coefficient associated with the transformation function of exports *i*
χ_i^{XEU}	share coefficient of supply to EU15 in total supply of commodity *i* to foreign markets
χ_i^{XCEE}	share coefficient of supply to CEEC10 in total supply of commodity *i* to foreign markets
χ_i^{XBG}	share coefficient of supply to Bulgaria in total supply of commodity *i* to foreign markets
χ_i^{XRW}	share coefficient of supply to RoW in total supply of commodity *i* to foreign markets
d_i	shift coefficient associated with the CES function of aggregate demand of commodity *i*
δ_i^{DD}	share coefficient of demand for domestic good *i* in aggregate demand ($1-\delta_i^{DD}$ hence represents the share coefficient of demand for imported varieties in aggregate demand)
ρ_i	Armington constant elasticity of substitution between imported and domestically produced good *i* (hence $2\rho_i$ represents the Armington constant elasticity of substitution between imports from the four trading regions)
e_i	shift coefficient associated with the CES function of demand for imports of good *i*
ε_i^{MEU}	share coefficient of demand for imports from EU15 in total import demand of good *i*
ε_i^{MCEE}	share coefficient of demand for imports from CEEC10 in total import demand of good *i*

Box A1 continued

ε_i^{MBG}	share coefficient of demand for imports from Bulgaria in total import demand of good *i*
ε_i^{MRW}	share coefficient of demand for imports from RoW in total import demand of good *i*
tm_i^{EU}	benchmark tariff rates applied by Romania on imports of good *i* from EU15
tm_i^{CEE}	benchmark tariff rates applied by Romania on imports of good *i* from CEEC10
tm_i^{BG}	benchmark tariff rates applied by Romania on imports of good *i* from Bulgaria
tm_i^{RW}	benchmark tariff rates applied by Romania on imports of good *i* from RoW
γ	expenditure share coefficient of private consumption in household income associated with the Cobb-Douglas utility function ($1-\gamma$ hence represents the share coefficient of private savings)
η	benchmark share of transfers from the household to the government in total income
Ω	shift coefficient associated with the private consumption Cobb-Douglas function aggregating domestic and imported varieties
ϕ_i	share coefficient of consumption of composite good *i* in total private consumption
Λ	shift coefficient associated with the investment Cobb-Douglas function ggregating domestic and imported varieties
π_i	share coefficient of investment of composite good *i* in total investment
u_{LD}^0	unemployment rate of land
u_L^0	unemployment rate of labour
u_K^0	unemployment rate of capital
Φ_{LD}	elasticity of unemployment of land with respect to return to land
Φ_L	elasticity of unemployment of labour with respect to pay
Φ_K	elasticity of unemployment of capital with respect to return to capital

Box A2: Welfare effects within the partial equilibrium context of a market for a single homogeneous good

The graph is adapted from Schiff and Winters (2003). The country faces horizontal import supply curves from the EU and the RoW following the small open economy assumption. It is assumed that imports of the respective good from EU and the RoW face equal tariff rates, and that a non-member country represents the low-cost import supplier, implying that the home country imported initially from RoW at world prices p_{RoW}. With the elimination of tariffs on EU imports, the price of imports falls from P_{RoW} + t to P_{EU}, domestic consumption increases from Q_1 to Q_2, domestic production decreases from Q_3 to Q_4, imports expand from Q_1Q_3 to Q_2Q_4 consumers gain A+B+C+D, producers lose A, whilst the government loses revenue equivalent to the area C+E. Hence, net welfare effects are equal to the area B+D-E, which can be positive or negative. Therefore, with a discriminatory unilateral elimination of tariffs on imports, the home country switches entirely from imports from the RoW to imports from EU members. This on one hand displaces domestic production creating trade and generating welfare gains (area B+D) due to the fall in domestic prices and on the other hand reduces welfare (area E) as the country is now paying more for its imports (p_{EU} instead of p_{RoW}) due to its trade diverting effects.



[1] We are grateful for valuable comments made by Colin Kirkpatrick on this revised version of the paper.

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[4] AGE models are commonly known in the literature as Computable General Equilibrium (CGE) models. Nevertheless, in this paper the term AGE rather than CGE is employed following Shoven and Whalley (1984) and Hertel (1999). This is because the aim of such models is to turn classical Walrasian GE theoretical structures "from an abstract representation of an economy into realistic models of actual economies" (Shoven and Whalley, 1984).

[5] According to Walras, general equilibrium implies that in an economy where consumers are endowed with factors and demand produced goods, and firms demand factors and produce goods with a fixed coefficients production technology (or more generally, a constant returns to scale production function), both output and factor markets clear, whilst perfect competition assures that producer prices equal the costs of production for every operating activity.

[6] A few other studies have adopted a partial equilibrium approach to assessing the potential impacts of Romanian agriculture joining the EU's CAP (EC, 2002, Wahl et al., 2000, Donnellan et al., 2002, the latter just mentioning a model for Romania in the pipeline). Others have analysed the effects of accession upon Romanian agriculture and rural development through a SWOT analysis (Manoleli et al., 2004) or deal with the overall process of Romanian integration (Ciupagea, 2001, Ciupagea et al., 2004). However, these later studies generally deal with non-agricultural issues and construct macroeconomic models for Romania where agriculture is modelled only as an exogenous sector.

[7] The main explanation is that quotas apply only to marketed output, and the production of raw milk and sugar beet in Romania is still largely driven (around 40 percent) by subsistence activities that do not fall under CAP rules.

[8] A single-country compared to a multi-country AGE approach focuses solely on the economic perspectives for one country and consequently tends to provide a more detailed examination of likely effects and the economic mechanisms that trigger the respective effects

[9] In fact these represent a mix of equalities and inequalities formulated and are formulated as an MCP (mixed complementarity problem). Using the MCP setup the first condition reads: -profit≥0, output≥0, output^T(-profit)=0; the second reads: (supply-demand)≥0, price≥0, price^T(supply-demand)=0; and the third reads: (endowment-income)≥0, income≥0, income^T (endowment-income)=0 (Paltsev, 2004). Thus output is the associated variable with the zero profit condition, the price vector is the associated variable with the market clearance condition, and income is associated with the income balance condition.

[10] General equilibrium problems have been approached in the last three decades more from a computational and practical perspective due to the pioneering work undertaken in the 1950s, 1960s and 1970s notably by James Meade, Harry G. Johnson, Arnold Harberger, H. Scarf, John Shoven and John Whalley.

[11] The team employed the database format used by the GTAP (Global Trade Analysis Project) model. This represents a global applied general equilibrium model frequently employed in the AGE literature by various authors and developed by a team of researchers at Purdue University under the coordination of Thomas Hertel.

[12] Other modifications include the transfer of intermediate consumption of services to the intermediate consumption of raw milk and sugar cane and beet associated with the production of dairy and sugar products, the modification of any negative entries for the value added of capital to reflect positive numbers, and the balancing of the initial Banse (2001) SAM using the RAS technique.

[13] Activities that receive production subsidies are nine agricultural sectors (wheat, other grains, vegetables and fruits, oilseeds, cane and beet raw sugar, other crops, live animals, raw milk, other animal products) and some producing other primary products (*e.g.* coal and other minerals). However, according to the data these represent only 1-2 percent of the total activity expenditure.

[14] Thus, GDP at market prices equals GDP at factor prices plus indirect taxes and import tariffs (on the supply side) or total final demand (private consumption, government, investment, and changes in

inventories) plus exports minus imports (on the demand side). GDP at factor prices equals value added payment to factors or gross factor income (including capital depreciation).

[15] A major objection is raised in the literature with reference to the benchmark equilibrium data set characterising a SAM, namely the assumption that the benchmark equilibrium is a "representative" equilibrium. In other words, since SAMs usually rely only on the data for a single year it is assumed that during that year no major stochastic anomalies were present and strong enough to influence the model (Petersen, 1997). Unfortunately, data sets for Romania for more recent years are yet not made available.

[16] The Walras law states that for any given set of prices, the market value of supply equals that of demand (and the total value of consumer incomes equals consumer expenditures), and if demand equals supply on *n-1* markets, then the equality must hold on the *n*th market. In other words the Walras law argues that one equation is always redundant. This renders a very powerful check on the consistency of the AGE model that confirms that there were no errors in data base management, modelling coding or even theoretical structure (Hertel, 1999).

[17] Van Tongeren et al. (2001) associate the short-term analysis with fixed resources, and the long term with fully mobile factors of production and endogenous capital accumulation.

[18] Cross-hauling refers to the fact that countries often trade with each other goods and services that belong to the same category.

[19] Closure rules can be mathematically explained by the need to provide the model with an equal number of equations and endogenous variables. From an economic standpoint closure rules introduce plausible macroeconomic constraints that impact the microeconomic behaviour of economic agents as well as additional endogenous variables that balance the respective constraints (Thissen, 1998).

[20] A pure "Walrasian" type of an AGE model does not contain any macro elements and is intended to be a computational version of strict general equilibrium models (Davies, 2004).

[21] The SAM that reflects data specific for a country in transition displays earnings on capital accruing to the government. We assume here that the government owns fixed (sector-specific) capital particularly in three broad sectors: other primary products ("opp"), other manufacturing products ("omp"), and services ("svc").

[22] The fundamental indeterminacy of investments refers to the fact that there is no dynamic or intertemporal mechanism to determine the level of investment in a static model, and the neoclassical closure rule hence represents a solution to this problem (Hertel, 1999).

[23] The unemployment rate in Romania in 1997 stood at 8.9 percent (National Institute of Statistics, 2002).

[24] The elasticity of unemployment with respect to pay is –0.1. This was derived from the literature that econometrically estimates wage curves and the corresponding elasticities for countries in transition. For example, Kállai and Traistaru (1998) suggest the presence of a wage curve in Romania and estimate a significant elasticity of unemployment to pay of –0.13 for 1993 and 1994. Walsh and Duffy (2002) find a local unemployment elasticity of pay for Poland of –0.1 over the period 1991-1996. Finally, Blanchflower (2001) estimates over the period 1990-1997 East European wage curves that produce a local unemployment elasticity of between –0.1 and –0.3.

[25] As a matter of fact there are 1494 equations and 1494 endogenous variables defining the model. However, according to the Walras law one equation is redundant, which is solved by fixing an endogenous (price or income) variable and choosing it as a *numeraire* (the price of foreign exchange in the example below). y This reduces the model to a square system of 1493 equations and 1493 endogenous variables. The 64 equations defining the model consist of 41 equations for each sector/commodity (41x23=943) plus 1 equation describing the demand for 23x23 (529) matrix of intermediate inputs, and plus 21 stand alone equations.

[26] The enlarged EU26 includes the current EU25 members plus Bulgaria that is scheduled to join in 2007.

[27] Moreover, the tariff rates used here represent an average across trading sectors and as import tariffs applied to the EU and CEEC were much lower in 1997 compared to those applied to the RoW, they underestimate initial levels of the MFN tariff rates and overestimate the applied tariffs originating from trading agreements with the EU and CEEC.

[28] The price of foreign exchange has been fixed and chosen as a *numeraire* in this example.

[29] The share of exports in production is equal to 1- β in the notation associated with the output transformation function displayed in the previous section.

[30] The predicted slight increase in household's real income could be traced out in detail due to the model's articulate microeconomic structure. Nevertheless, the complexity of the model makes decomposing the final real income effects, a tedious process that is not presented in this analysis.

[31] Even though, the misallocation of resources is to some extent eliminated, it is however to another extent merely shifted across trading partners.