# INTEGRATION AND TRANSITION ON EUROPEAN AGRICULTURAL AND FOOD MARKETS: POLICY REFORM, EUROPEAN UNION ENLARGEMENT, AND FOREIGN DIRECT INVESTMENT

- Four Essays in Applied Partial and General Equilibrium Modeling -



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Für Edda

"You cannot draw lines and compartments, and refuse to budge beyond them. Sometimes you have to use your failures as stepping-stones to success. You have to maintain a fine balance between hope and despair ... In the end, it's all a question of balance."

(Rohinton Mistry, A Fine Balance)

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# List of Abbreviations

AGE	- applied general equilibrium
APEC	- Asia-Pacific Economic Cooperation
CAP	- Common Agricultural Policy
CDE	- constant difference of elasticities
CEA	- Central European Associates
CEC	- Central European countries
CEC-7	- seven Central European countries (model region)
CEEC	- Central and Eastern European countries
CEFTA	- Central European Free Trade Area
CES	- constant elasticity of substitution
CET	- constant elasticity of transformation
cif	- cost, insurance, freight
ECU	- European Currency Unit
EFTA	- European Free Trade Area
ERS	- Economic Research Service
EU	- European Union
EU-12	- European Union (12)
EU-15	- European Union (15)
EV	- Equivalent Variation
FAO	- Food and Agriculture Organization
FDI	- foreign direct investment
fob	- free on board
FSU	- Former Soviet Union
GATT	- General Agreement on Tariffs and Trade
GDP	- gross domestic product
GEMPACK	- General Equilibrium Modeling Package
GEWISOLA	- Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus
GQ	- Gaussian Quadrature

gro	- other grains (model sector)
GTAP	- Global Trade Analysis Project
IMF	- International Monetary Fund
met	- meat products (model sector)
mil	- milk products (model sector)
MNE	- multinational enterprise
mnfcs	- manufactures (model sector)
ngc	- non-grain crops (model sector)
NTB	- non-tariff barriers
OECD	- Organization for Economic Co-operation and Development
ofp	- other food products (model sector)
olp	- livestock products (model sector)
opp	- primary products (model sector)
R&D	- research and development
RSV	- raw sugar value
SAM	- social accounting matrix
SPEL	- Sektorales Produktions- und Einkommensmodell für die Landwirtschaft
svces	- services (model sector)
TFP	- total factor productivity
UN	- United Nations
UNECE	- United Nations Economic Commission for Europe
UNCTAD	- United Nations Conference on Trade and Development
UR	- Uruguay Round
USDA	- United States Department of Agriculture
US\$	- United States Dollar
wht	- wheat (model sector)
WTO	- World Trade Organization

#### 1 General Introduction and Overview

#### 1.1 Statement of the Issues

European markets for agricultural and food products are characterized by two major processes over the last decade: integration and transition. The term integration is mostly used with respect to the Common Agricultural Market, the Common Agricultural Policy (CAP) and the Monetary System within the European Union (EU). Since the foundation of the European Economic Community in 1957, agricultural and food markets have become more and more integrated. This process will be further advanced by the introduction of a common currency in 1999. On the other hand, the term transition is usually assigned to the process of economic reform and restructuring in Central and Eastern European countries (CEEC) after the breakdown of socialist regimes and central planning. The transition process from plan to market has been going on for about a decade now, and countries like Poland, Hungary, and the Czech Republic have made tremendous progress in establishing market economic systems. Other countries, like the majority of the Newly Independent States in the Former Soviet Union, are lagging behind and have quite a way to go in transforming their economies. Hence, the term "transition" will remain important for some time in Central and Eastern European food industries.

However, it can also be stated that *transition* processes become more and more relevant in *Western* Europe. The Common Agricultural Policy is constantly changing which is caused by internal as well as external reasons. Budget limitations, administrative problems and reduced political acceptance force the EU Commission to modify the CAP. In addition, negotiations in the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO) have and will put considerable external pressure for reform on EU agriculture. Although the last CAP reform in 1992 brought about the most profound changes to European agricultural policy in the last 40 years, already the next steps are outlined in the Agenda 2000 proposals. The Agenda 2000 is supposed to provide a suitable framework for European agriculture and food markets at the beginning of the next century. It can be said that EU agriculture faces an on-going process of transition from high government protection towards more and more open competition on world markets. Moreover, the Agenda 2000 indicates that the future EU agricultural policy will have to include broader aspects concerning regional development and environmental protection.

On the other hand, *Central and Eastern European* countries are facing the challenges as well as the opportunities of economic *integration*. While traditional trade relationships from socialist times, e.g. between the Former Soviet Union and the Central European countries, have collapsed, the most important trading partners are now in Western Europe. Most transition countries have preferential trading agreements with the European Union. Moreover, the Central European Free Trade Agreement (CEFTA) was created in order to explore the benefits of open markets within the region. The same applies to several common market arrangements among the Newly Independent States. However, market integration also means that producers in CEEC are facing Western import competition. Especially in the food industry, this has led to serious decreases in domestic production, as food processing was generally one of the least competitive sectors in centrally planned economies.

Probably the strongest element of transition and East-West integration in the near future will be the prospective Eastern enlargement of the European Union. Once the first five candidates for EU membership, the Czech Republic, Estonia, Hungary, Poland and Slovenia, will be in the Union, they will also be integrated in the Common Agricultural Policy, even though there might be a considerable adjustment period. Later, the process of integration might continue with the accession of even more new members from the CEEC region, or with the extension of the common currency towards the more prosperous Central European countries like Poland or Hungary. By that time, these countries might not be called transition countries any more.

A further important aspect of East-West integration is the flow of foreign direct investment (FDI) by Western food companies into the transition countries. In the general process of economic globalization, the movement not only of equity capital, but also of related technical and management know-how through multinational firms has become a very important issue. Even in socialist times a few Western firms had jointventure agreements with state-owned companies in CEEC. Since the beginning of economic and political transition, the inflow of foreign capital into this region has risen sharply. FDI can be expected to play an important role not only in the process of economic restructuring in the transition economies, but also with respect to regional integration on European food markets. However, to which extent the potential of foreign firms can actually be realized, depends to a large part on the policy environment in the recipient countries.

In this study, various aspects of European integration and transition, i.e. agricultural policy reform, EU Eastern enlargement, and FDI in transition countries, are analyzed using applied partial as well as general equilibrium modeling approaches. The major objective of the study is to quantify the separate effects of these economic processes, and to show important linkages and interactions between them. First, for the case of a further CAP reform, the effects of uniform land and labor subsidies on output and factor markets are analyzed in a general equilibrium framework. Second, based on the uniform land subsidy, a prospective EU enlargement is simulated in the same modeling framework. Implications for production and trade, government budgets, and regional welfare in the EU as well as the new members are demonstrated. Third, the economic impact of sector-specific FDI inflows into the the transition economies is analyzed in a general equilibrium model is used for simulating the interaction between FDI, trade policy intervention and imperfect competition in the Polish sugar industry. In this case, the policy choice is also related to the potential integration of Poland into the EU.

For the researcher, the variety of applications in this study reveals various strengths and weaknesses of the modeling approaches and shows specific needs for further model improvements. Moreover, the model exercises provide useful results for institutions and policy-makers who are responsible for shaping the framework around the integration and transition processes in Europe.

#### 1.2 Structure of the Study

The main part of this study consists of four previously published essays which cover various issues mentioned in the last section. Preceding the actual analyses, Chapter 2 provides a descriptive overview of applied general equilibrium (AGE) modeling as well as the structure of a specific AGE model developed by the Global Trade Analysis Project (GTAP). In Chapter 3, 4 and 5, the GTAP model is used for the analysis of EU agricultural policy reform, Eastern enlargement, and FDI in transition countries,

respectively. In Chapter 6, a new partial equilibrium model is developed for analyzing the impact of FDI in the Polish sugar industry.

Chapter 2 starts with a brief overview of applied general equilibrium modeling. Then, the structure of the GTAP model is explained in detail by referring to the actual computer software code. Furthermore, the GTAP database as well as possible extensions to the standard model are discussed. The complete model code is listed in the appendix to Chapter 2. This rather technical information is provided in order to make later model applications more transparent and replicable for the interested reader. For the same reason, the model code necessary for implementing the relevant scenarios in Chapter 3 through 5 is also given in respective appendices.

In Chapter 3, recent developments and proposals for further reform of the EU Common Agricultural Policy are discussed. Based on a study by KIRSCHKE et al. (1997), new options for a simplified and more transparent policy regime are developed. Major elements are uniform labor and land subsidies, combined with a partial as well as complete removal of border protection measures. Several policy scenarios are defined and analyzed in a general equilibrium framework. An earlier version of this paper was published in HEROK and LOTZE (1997).<sup>1</sup>

Chapter 4 provides an AGE analysis of an EU Eastern enlargement under a new CAP. External restrictions, like tariff bindings from the GATT Uruguay Round, are important in formulating a policy regime which would facilitate the enlargement. In this paper, a policy regime based on uniform land subsidies, as discussed in Chapter 3, is taken as an option for preparing EU agriculture for the prospective integration of new members from Central and Eastern Europe. The actual enlargement is assumed to occur in the year 2005. Various scenarios are defined in which different development paths for the transition economies are also taken into account. Using the GTAP model, a forecast up to the year 2005 is conducted under varying conditions. Subsequently, the integration effects are analyzed by modeling a customs union between the EU and the new

<sup>&</sup>lt;sup>1</sup> Claudia A. Herok contributed to this chapter an overview of the current policy debate regarding further CAP reform. She was also supportive in discussing the model results.

members. Earlier versions of this paper have been published in HEROK and LOTZE (1998) and accepted for publication in HEROK and LOTZE (forthcoming).<sup>2</sup>

In Chapter 5, the impact of FDI by Western firms on the transition process in CEEC is analyzed within the GTAP modeling framework. The paper starts with a theoretical overview of the potential effects of FDI on recipient economies. Recent data on sector-specific FDI flows into the transition countries are presented which are then used for the empirical analysis. The model distinguishes between various sectors for primary agriculture and the food industry as well as manufactures and services. Several scenarios are defined, taking important features like technology transfer effects and labor market rigidities into consideration. Previous publications of this work can be found in LOTZE (1997a; 1997b; 1998).

Finally, in Chapter 6 also the effects of FDI in the transition process are analyzed, but a different approach is taken. Here, the focus is very specifically on one sector and one country, i.e. the sugar industry in Poland. A relatively simple, partial equilibrium model is developed for analyzing the interaction between FDI, distorting trade policies and imperfect competition on a domestic market in the recipient country. Input linkages to sugar beet producers are also included in the model. Various options with respect to the Polish sugar policy are formulated. These policy options are also related to the expected EU Eastern enlargement. Due to the debate on a further CAP reform, it is currently not clear how the EU sugar regime might look like at the time of enlargement. However, the type of the policy intervention will have important implications for the impact of FDI in the Polish sugar industry. A previous version of this paper was published in LOTZE (1997c).

Although the individual chapters of this study partly overlap in their topics and methodology, they can be read independently from each other. Therefore, all the references and appendices related to a certain chapter are given right at the end of the chapter. Footnotes are numbered separately for each chapter. Having more or less independent chapters also implies that certain repetitions are unavoidable. For example, each of the chapters in which the GTAP model is used includes a very brief description of the model structure in order to make the results plausible. For further details on the

<sup>&</sup>lt;sup>2</sup> In this chapter, Claudia A. Herok provided valuable information about the preparation for an EU Eastern enlargement. She was also very helpful in formulating the model scenarios as well as discussing the results.

modeling technique as well as possible extensions to the standard model the reader is referred to Chapter 2.

#### 1.3 Main Findings

As already mentioned in Section 1.1, the EU Common Agricultural Policy is constantly changing. After the last reform in 1992, a lot of scope for further adjustment remains. On the one hand, there is a rising pressure for more external liberalization which is caused by the on-going multilateral trade negotiations in the WTO and the prospective Eastern enlargement of the EU. On the other hand, there is also growing internal demand for simplified policy measures, as the CAP has become ever more complicated and expensive to administer. Direct factor subsidies have been discussed as an alternative form of income support to farmers which could be less distorting with respect to domestic consumers and international trade. In Chapter 3, partial and complete liberalization scenarios for the CAP are analyzed in connection with uniform compensation payments related to agricultural land or labor. The level of the factor subsidies is calculated by taking the total amount of current compensation payments and dividing it by the total amount of agricultural land or labor. For matter of comparison, additional scenarios without any compensation are also simulated. An AGE model is a suitable tool for this analysis, as factor movements into and out of agriculture are explicitly taken into account.

Due to reduced border protection, agricultural output in the EU drops in all scenarios. The model results show that the effects of the factor subsidies on output levels are very small compared to the scenarios without any compensation. Hence, distortions with respect to domestic product markets and international trade are almost negligible. World market prices for all agricultural and food products rise, and it appears that the EU would be able to fulfill its requirements from the GATT Uruguay Round even in the partial liberalization scenarios. In addition, EU budget expenditures are reduced between 17 percent under partial liberalization and 42 percent under complete liberalization. However, uniform factor subsidies cause new distortions on land and labor markets. In the case of a land subsidy, land rents are seriously driven up which favors land owners, but not necessarily active farmers. A labor subsidy significantly slows down the employment reduction in agriculture after further liberalization of the CAP. For any kind of factor subsidy, it has to be kept in mind that the specific design of

these new policy instruments would have an impact on factor use and prices. This has been neglected in the current AGE model. Moreover, other studies have shown that, even under partial liberalization, severe adjustment costs occur on the farm level. This indicates that there might be a discrepancy between the aggregate AGE model reactions and the adjustment possibilities for the individual farm.

If there is a political consensus that farm income support will have to be provided by the EU for some time, uniform land subsidies might be a useful option for a future development of the CAP, although they are not without their own problems. Land subsidies are probably easier to administer than labor subsidies, and they could be more easily linked to region-specific environmental standards. This is an important feature, since aspects of environmental protection will become more relevant to EU agriculture in the future. In any case, factor subsidies should be seen only as a further step of the CAP towards a simplified policy regime and generally lower protection levels. From an economic point of view, any kind of subsidy should be phased out after a certain adjustment period, unless it pays for the provision of certain public goods which are not remunerated by the market.

In Chapter 4, a uniform land subsidy is taken as the basic policy instrument which could prepare the CAP for the integration of several transition countries. The Eastern enlargement will be a big challenge for the EU in terms of administration and budget expenditures. For both reasons, the CAP will have to be modified prior to the integration of new members. The model calculations in Chapter 4 try to illustrate the effects of an EU enlargement in the year 2005 under partial and complete liberalization of the CAP, in connection with a uniform land subsidy. The group of new members in the model consists of seven countries (CEC-7).<sup>3</sup> In order to make the integration scenarios more realistic, four different development paths until 2005 are considered. Various rates of economic growth are assumed for the CEC-7 due to uncertainty about the general economic development in the near future. Several difficulties arise with respect to transferring the CAP to the new members. It is, for example, by no means clear whether farmers in these countries will be eligible for any direct payments under the current CAP. Moreover, the Central European countries have their own tariff bindings under the WTO regulations which should not be violated after an EU

<sup>&</sup>lt;sup>3</sup> These are Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia.

integration. As a compromise, in the model simulations the land subsidy is transferred only in relative terms according to local factor price levels.

After EU integration under *partial liberalization* of the CAP, domestic prices and output for non-grain crops and meat products rise strongly in the CEC-7. For milk products, the quota regulation is applied which leads to domestic price increases of more than 60 percent. Trade creation occurs especially in agriculture and food products where bilateral trade flows between CEC-7 and the old EU-15 nearly double. Trade diversion effects occur to the disadvantage of the Former Soviet Union. The transfer of land subsidies to the new members causes additional budget expenditures for the EU-15 at about 5 billion ECU. However, in the partial liberalization scenarios this is nearly balanced by reduced budget outlays for the CAP in general. Under complete *liberalization* of the CAP, output in agriculture and food products declines in the CEC-7 after EU integration. However, during the period up to the year 2005 they are able to grow faster under this scenario, and the total effect leaves them better off compared to a partial CAP liberalization. Moreover, huge budget savings on the side of the EU-15 would give room for much more structural support to the new member countries. Increased trade within the enlarged EU together with budget transfers from the old members lead to overall welfare gains for the CEC-7 between 1.7 and 2.4 percent of gross domestic product (GDP) at pre-enlargement levels. However, these numbers include only the static welfare gains from creating the customs union. If more dynamic effects like reduced political uncertainty and capital accumulation were taken into account, the calculated welfare gains from enlargement were probably much larger.

In view of the recent Agenda 2000 proposals by the European Commission, partial liberalization of the CAP certainly seems to be a realistic option for the upcoming enlargement, although problems with WTO restrictions should not be neglected. If current CAP instruments would be transferred to the new members, they are very likely to create severe distortions in these emerging market economies. This would also apply to a uniform land subsidy which would certainly create distortions on the land market. However, as already mentioned, such a simple policy instrument would be less distorting than product-specific payments, and it would be much less demanding with respect to administrative requirements. To the Central European countries, these arguments are even more relevant than to the current EU. Principally, agricultural policies in an enlarged EU should be as open as possible to world market competition.

This would prepare the new members for exploiting their comparative advantages in the agricultural and food sector while avoiding painful adjustments at later times, which Western European agriculture currently has to go through.

A further aspect of East-West integration, i.e. foreign direct investment activities by Western companies in the CEEC, is analyzed in Chapter 5. Since the political changes in Europe in 1989, total FDI flows into the transition countries have increased rapidly. However, the country and sector distribution has been very uneven. For example, Slovenia, Hungary, and the Czech Republic have received much higher inflows of foreign capital, relative to their levels of GDP, than most countries in the Former Soviet Union. In all countries, the share of agriculture in total capital inflows is negligible, while the food processing industry received on average 11 percent of all FDI in the CEC-7, and 8 percent in the FSU. Four experiments are conducted in Chapter 5 in order to estimate the impact of FDI in the transition economies up to the year 1996. By using the GTAP model with data on sector-specific capital inflows, the effects of FDI can be separated from other simultaneous influences during the simulation period. Moreover, technical change can be implemented in the model in order to capture the know-how transfer related to FDI. Labor market imperfections which prevail in the transition countries are also considered. However, while imperfect labor mobility can be easily implemented in the model, real unemployment does not occur in the current version.

Generally, expectations in the CEEC are high with respect to the contributions of FDI to the process of economic restructuring and growth. However, so far the aggregate model results show a rather modest impact. For the time period between 1992 and 1996, an additional annual growth of GDP is calculated between 0.4 and 0.8 percent for the CEC-7, and about 0.2 percent for the FSU. Technology transfer effects account for about half of the total gains. The model also provides sector-specific employment effects. It becomes clear that labor is moving out of sectors with high shares of foreign investment. This is partly caused by substitution effects between capital and labor. Furthermore, additional technical change has not only output enhancing, but also input saving effects. More capital intensive new technologies introduced by foreign firms tend to use primary as well as intermediate inputs more efficiently. In the case of the food industry, this causes a decline in the domestic demand for agricultural products. Hence, in the model, domestic agriculture in the transition countries gains relatively little from FDI by Western food processing companies. Imperfect labor mobility between sectors does not alter the results significantly.

The model experiments in Chapter 5 indicate that FDI should not be viewed as a major source of external finance in the transition process. Foreign capital can only be a supplement to domestic savings which have to provide the basis for economic development. Nevertheless, FDI may provide initial starting points for productivity growth and spillovers for local producers. The dynamic effects of management knowhow transfer and "learning by watching" are, of course, very difficult to quantify.

Two important aspects with respect to the impact of FDI have been omitted in the AGE analysis in Chapter 5: government intervention and imperfectly competitive product markets. Government taxation and trade policy interventions will have important implications for foreign investors. Moreover, FDI is likely to change the competitive situation in the transition economies, where especially the food industry is often still dominated by state authorities.

In Chapter 6, the interaction between FDI, trade policies and imperfect competition is analyzed for the case of the sugar industry in Poland. The Polish government plans to privatize its sugar factories with participation of foreign firms in the near future. Western European sugar companies already show an interest in this sector, since Poland has very favorable conditions for sugar beet production, and it will be one of the first new members in the EU. This also implies hat the highly protective EU sugar policy would be applicable to Polish producers. In preparation for EU membership, Poland itself has already introduced a quota regime for sugar production. For the analysis, a new partial equilibrium model has been developed which is based on recent theoretical work in the literature. The model captures various types of trade policy intervention, government taxation and oligopsonistic behavior in the processing industry. Agents in the model are local as well as foreign sugar processors, sugar beet suppliers, consumers and the local government. The government is assumed to maximize domestic welfare by charging an output tax on sugar.

In the model, domestic sugar production is partly displaced by more productive foreign firms. This is clearly welfare improving, although the net effect for sugar beet farmers is ambiguous. If total sugar production does not rise, e.g. under a quota system, the demand for sugar beets is reduced due to higher productivity in the processing stage. The size of the overall welfare gain crucially depends not only on the level of investment, but also on the policy instruments in place. Under high domestic protection, local as well as foreign sugar processors gain a higher producer surplus, but foreign firms can transfer their share abroad, as far as they are not taxed. The optimal tax rate rises with the level of investment. In the case of a restrictive quota regulation, part of the quota rents also accrue to foreign firms. Local consumers suffer from high domestic prices which additionally reduces the overall welfare gain for the recipient country. Under certain circumstances, i.e. a low investment level and a deficiency payment system with high domestic producer prices, the overall welfare effect of FDI can even be negative. The positive impact of FDI on domestic competition is rather small. Sugar beet producers gain significantly from higher producer prices, but this is merely a redistribution of rents which were captured by the imperfectly competitive processing industry before.

From the analysis in Chapter 6 it can be concluded that it is not in the best interest of a transition country to create investment incentives through distorting policy interventions. FDI will bring about sizeable benefits to the domestic economy only in the case when foreign firms enter a market because of differences in production costs or other real locational advantages. Under protectionist policy regimes, the positive contribution of FDI to local welfare is much smaller than in the case of undistorted markets. Part of the rents created through policy intervention accrue to foreign companies and cannot fully be captured by the local government through taxation. Increased competition in the processing industry has considerable advantages for raw input suppliers. This can be an important policy objective with respect to rural development in transition countries. However, the corresponding overall welfare improvement is rather small.

#### **1.4 Implications for Further Research**

The analyses in this study provide plenty of scope for further research. The first group of possible extensions includes the consideration of additional policy problems and scenarios as well as more detailed presentation of the results. The second group consists of advances in the modeling techniques. With regard to additional policy scenarios, the distorting effects of land and labor subsidies on output and factor markets deserve further attention. Especially the influence of various model parameters on factor movements and factor price changes might be important. Systematic sensitivity analysis needs to be considered in this respect. In addition to uniform subsidy schemes, the precise proposals for the Agenda 2000 as they are now available should be modeled, which would require further disaggregation concerning agricultural commodities and various types of premia. A new database with a more detailed sector coverage in agriculture and food has been published by the Global Trade Analysis Project. This is certainly a good starting point for more precise agricultural policy analysis in the AGE framework. Implicit modeling of the EU budget would also make these policy scenarios more realistic. In addition, recent progress in welfare decomposition techniques facilitates a better representation of the model results.

Furthermore, various aspects which have been treated separately in this study should be combined into more comprehensive model simulations. For example, the analysis of an EU enlargement would become more realistic under a scenario covering the Agenda 2000 as well as endogenous FDI flows between regions. The consideration of a longer adjustment period with partial transfer of certain policy measures to the new member countries might be an additional option. The connection between FDI, trade policies, and imperfect competition in the AGE framework could be established by drawing on the modeling exercises in Chapter 5 and 6. Endogenizing the decisions of foreign firms between export activities and FDI as well as the decision between various types of FDI would be further useful extensions to the scenarios presented in this study.

This leads to further advances in the modeling techniques. In order to capture endogenous capital movements between regions more realistically, a dynamic modeling approach would be required. There are some examples of GTAP applications with endogenous capital accumulation which could be taken as a guideline. Issues like knowhow transfer and technology spillovers could also be treated more appropriately in a dynamic setting. Another important area of model improvement is the implementation of imperfect competition and unemployment, as these issues are crucial in the transition process. Some progress has been made in the GTAP framework, and Chapter 6 also provides a useful concept for further extensions. The explicit introduction of multinational firms into an AGE model would be an important improvement for capturing the effects of FDI. Generally, sector-wide model reactions could probably be made more plausible by taking into account the reactions and decisions of individual firms. For example, farm-based agricultural sector models show that there is often a discrepancy between adjustment possibilities of single firms and model reactions which are determined by sector-wide elasticity parameters. Firms' reactions are often restricted by sunk costs and path dependence which are usually not reflected in aggregated sector or AGE models. Moreover, especially in the process of transition, economic agents might reveal a behavior which differs from the traditional assumptions of utility and profit maximization. However, modeling structural change in a certain industry through entry or exit of individual firms is very difficult, since this is a highly non-linear process.

The long-run objective in applied economic modeling should be to close the gap between the aggregated sector level and single-firm models. Coming from the AGE approach, this would imply the development of a dynamic model with a detailed sector disaggregation, capturing multinational firm activity as well as imperfect competition. In practice, it is often difficult to provide the linkages down to the single firm, as consistent interfaces between different modeling approaches are often hard to define. However, on the basis of single-farm models, some progress has already been made in deriving sector wide model reactions by aggregating many single entities for a certain region (BALMANN et al. 1998).

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#### 2 Applied General Equilibrium Modeling and the Global Trade Analysis Project

#### 2.1 An Introduction to Applied General Equilibrium Modeling

Quantitative modeling of markets and policies has become ever more demanding in the process of economic development. Modern economies are characterized by multiple linkages between domestic input and output markets. In addition, international trade and factor movements establish further connections between countries and regions within the global economy. As the world economy becomes more integrated, there is also an increasing demand for quantitative policy analyses on a global scale. Important examples are the Uruguay Round (UR) negotiations under the General Agreement on Tariffs and Trade (GATT) as well as regional trade issues like the expansion of the European Union (EU), the Asia-Pacific Economic Cooperation (APEC), and Mercosur in Latin America (HERTEL 1997, p.1.2).

Applied general equilibrium (AGE) models are powerful tools for analyzing these complex relationships. They provide a consistent framework, based on neoclassical economic theory, for conducting controlled experiments with respect to policy issues on the level of the whole economy (POWELL 1997, p.iii). AGE models combine certain characteristics of disaggregated partial equilibrium models with those of highly aggregated macroeconomic models. Modern computer and software technology meanwhile allows the modeling of a large variety of disaggregated markets and sectors in an AGE framework, which was until recently the main feature of partial equilibrium models (BAUER and HENRICHSMEYER 1989; TAYLOR et al. 1993). Moreover, AGE models establish linkages between all sectors within the economy, while taking into account the limited endowments with basic resources like land or labor. These models are closed in a macroeconomic sense, as they include the equalization of economy-wide savings with overall investment. Since policy measures are usually sector specific, disaggregated AGE models provide results with respect to costs and benefits for various economic agents which is usually not feasible with empirical macroeconomic models (SHOVEN and WHALLEY 1992, p.1).

Policy analysis with a focus on agriculture and food was traditionally a domain of partial equilibrium approaches. However, in this area the application of AGE models

can be useful for two reasons. First, if agriculture and the food industry have a large share in the economy, like in most developing countries and some transition countries, changes in agricultural policies or the development of the food industry may have a significant impact on the rest of the economy. Hence, it would be inappropriate to neglect corresponding factor movements between sectors and the effects on income redistribution. Changes in savings and investment also contribute to a more realistic picture of the economy-wide impact of sector policies. Second, changes in the macroeconomic environment, like monetary policy or exchange rates, or other exogenous shocks, like energy taxes, have an impact on the situation in the agricultural sector. Endogenous treatment of these issues usually goes beyond the capacity of partial equilibrium models.

AGE modeling started out with simple two-sector models of one country (MEADE 1955; JOHNSON 1958; JOHANSEN 1960; HARBERGER 1962). Gradually, the variety of sectors and markets in the models was increased, as improving computer technology and mathematical algorithms provided the means to solve these models consistently. ADELMAN and ROBINSON (1978) added another level of complexity by incorporating international trade between regions. A good survey of AGE modeling is given by SHOVEN and WHALLEY (1984).

The most important applications of multi-region AGE models were analyses of the distorting effects of taxes, tariffs and other policies on production, trade and resource allocation. "The value of these computational general equilibrium models is that numerical simulation removes the need to work in small dimensions, and much more detail and complexity can be incorporated than in simple analytic models" (SHOVEN and WHALLEY 1992, p.2). Many different policy interventions can be analyzed simultaneously, which is important as the total impact might differ from the sum of all the isolated effects. In order to provide meaningful analyses for policy makers, in many cases a detailed model structure with respect to regions, commodities, and policy instruments is required. The model developed by the Global Trade Analysis Project, which will be discussed in Chapter 2.2, is an example of a multi-region, multi-commodity AGE model.

#### 2.1.1 The Basic Structure of an Applied General Equilibrium Model

The central idea of an AGE model is "to convert the Walrasian general equilibrium structure ... from an abstract representation of an economy into realistic models of actual economies. Numerical, empirically based general equilibrium models can then be used to evaluate concrete policy options by specifying production and demand parameters and incorporating data reflective of real economies" (SHOVEN and WHALLEY 1992, p.1).

The term general equilibrium was first elaborated by ARROW and HAHN (1971). A very simple AGE model would look like the following. Main economic agents in the economy are households and producers. Households have an initial endowment with resources and a set of preferences for various commodities. By maximizing their utility, household demand functions for commodities can be defined. Market demands are the sum of all individual households' demands. Commodity demands depend on all prices, and they are continuous, nonnegative, and homogeneous of degree zero. Moreover, they satisfy Walras' law which states: if, in an economy with n markets, n-1 markets are in equilibrium, then the last market also has to be in equilibrium. This is the same as to say that, at any set of prices, the total value of consumer expenditure is equal to total consumer income (SHOVEN and WHALLEY 1992, p.2). Producers have a certain technology, usually described by constant or non-increasing returns to scale, which they use for converting primary factors and intermediate inputs into final commodities. Producers are assumed to maximize profits. Since commodity demand is homogeneous of degree zero and supply is homogeneous of degree one, there is no money illusion in the economy and only relative prices matter within the model. One price is usually declared as the numeraire.

A standard AGE model is comparative static. The model is assumed to be in an equilibrium in the initial state. After an exogenous shock, like a policy intervention, a new equilibrium is achieved by searching a set of prices and production quantities for all commodities such that market demand equals market supply for all inputs and outputs. Under the constant-returns-to-scale assumption this assures that all output revenue is converted into factor income without any extra profits. The mechanism is demonstrated in Figure 2.1 in an Edgeworth-box diagram for a simple two-person, pure exchange general equilibrium model. There are two individuals, A and B, with their

preferences and an initial endowment of two goods at point E. The size of the box defines the total endowment of the economy.



Figure 2.1: Simple pure exchange general equilibrium model

Using individual preferences, a contract curve can be determined which is the locus of all tangencies of both individuals' indifference curves, like point *Z*. Trade can occur along the relative price line which runs through points *E* and *Z*. In a closed economy, any sales of good 1 by person *A* must be equal to purchases of good 1 by person *B*, and likewise for good 2. At point *Z* on the contract curve, the price line is tangent to the indifference curves, and net trade of both individuals is balanced (SHOVEN and WHALLEY 1992, p.38). Finding an equilibrium implies finding a price ratio where market excess demands for both goods are zero. In Figure 2.2, the two market excess demand curves,  $g_1$  and  $g_2$ , are shown depending on the price ratio  $P_1/P_2$ . In a two-goods economy it is actually sufficient to find a price ratio where excess demand on one market is zero. By Walras' law the other market is automatically in equilibrium. However, finding an equilibrium may be easy only in a very simple model. If the number of dimensions increases, a trial-and-error procedure becomes inappropriate. With higher dimensions, excess demand curves might be complex and the model might not converge to an equilibrium (SHOVEN and WHALLEY 1992, p.39). For solving

Source: SHOVEN and WHALLEY (1992, p.38).

complex models, powerful solution algorithms and computer software have been developed.<sup>1</sup>



Figure 2.2: Excess demand curves for a simple general equilibrium model

Source: SHOVEN and WHALLEY (1992, p.39).

The major prerequisite and the basis of any AGE model is a social accounting matrix (SAM) of the economy or the regions under consideration. It is a square matrix that provides a picture of all economic transactions in a country or region at a given point in time, usually a certain base year. A stylized SAM is shown in Figure 2.3. Linkages between sectors and agents in the economy are established by expenditures and revenues. Expenditures are listed in columns, while revenues are listed in rows. The SAM is based on the principle of double accounting which is applied to the economy as a whole. Each account must balance such that the row and column totals are equal (BROCKMEIER 1994, p.2; SADOULET and DE JANVRY 1995, p.274-276).

Sources and destinations of all value flows in the economy can be identified in a SAM. It represents a closed system of a circulating economy, starting with the provision of factors of production by private households, followed by the generation of factor income, private consumption and commodity demand, and ending with production and

<sup>&</sup>lt;sup>1</sup> Some examples will be given in Section 2.2.

factor use by firms. This system is completed by government agencies, international trading relationships and the balance of savings and investment on a regional or global level. Thus, the SAM provides a mirror image of the functional relationships and identities in a corresponding AGE model.

	Commodi- ties	Factors of production	Households	Government	Capital account	Rest of the world	Total
Commodi- ties	Intermediate demand		Private consumption	Government consumption	Investment	Exports	Total revenues
Factors of production	Factor demand						Factor income
Households		Factor supply					Household income
Government	Taxes and tariffs		Taxes				Government revenue
Capital account			Private savings	Government savings		Capital transfers	Total savings
Rest of the world	Imports						Imports
Total	Costs of production	Factor outlay	Household expenditure	Government expenditure	Total investment	Exports	

Figure 2.3: Example of a stylized social accounting matrix

Source: Adapted from BROCKMEIER (1994, p.2); SADOULET and DE JANVRY (1995, p.274-276).

As shown in Figure 2.3, commodities are used as intermediate inputs for the production of other commodities, for private and government consumption as well as exports and investment purposes. This generates revenue for producers in the first row account and causes expenditures in various column accounts. Factors of production like land, labor and capital are supplied by private households and used for final production. Thus, households generate income, while the government raises revenue by collecting taxes and tariffs. Moreover, households and the government provide savings to the capital account. External relationships to the rest of the world are established through exports and imports as well as capital transfers.

The intermediate input relationships between various industries in the upper left-hand corner of the SAM can be summarized in an input-output table. The square matrix design allows additional sector disaggregation, if this is required for specific model applications. For example, if the focus is on agriculture and the food industry, several sub-sectors may be defined for these sectors, while the rest of the economy remains highly aggregated (WIEBELT 1990, p.10-11; BROCKMEIER 1994, p.2; SADOULET and DE JANVRY 1995, p.276).

### 2.1.2 Procedure of a Typical Model Application

A typical application of an AGE model would include the following steps as shown in Figure 2.4. First, the base data for countries or regions which are covered in the model have to be collected. Second, the data have to be organized in a SAM and to be adjusted in order to achieve an initial equilibrium, i.e. overall income must be equal to overall expenditures, bilateral trade flows between regions have to be balanced, and producers' revenues have to be equal to total factor income. This is not a trivial point, as real world data often reveal inconsistencies and deficiencies.<sup>2</sup>

Figure 2.4: Flow-chart for a typical AGE model application



Source: Adapted from SHOVEN and WHALLEY (1992, p.104).

<sup>&</sup>lt;sup>2</sup> See Section 2.3 and GEHLHAR (1997) for more detail.

The third step in the model application is the calibration of unspecified model parameters. The term calibration means specifying the model in such a way that it is capable of reproducing exactly the numbers from the initial equilibrium data set. In essence this involves solving the model backwards for the parameter values while taking the initial data as exogenous. A complex AGE model is very demanding with respect to the number of model parameters. Most often not all of the necessary parameters are available from external estimates in other studies. Even if estimates are available, they might not be appropriate for a specific model. Hence, after the functional forms in the model are chosen and the available exogenous elasticity values are implemented, in the calibration run the model is solved for the missing parameters (SHOVEN and WHALLEY 1992, p.115-118). Very often this requires a parsimonious approach with respect to the overall number of parameters in the model, as the number of unknown parameters must not exceed the number of independent equations in the model. One method of reducing the number of parameters is the choice of so-called nested structures for the functional forms in the model (SHOVEN and WHALLEY 1992, p.94-100; HERTEL and TSIGAS 1997, p.20-28). In a replication run the model has to generate the initial data using the calibrated parameters.

Once the model is calibrated, the scenarios under consideration have to be defined and translated into the modeling framework. After policy shocks, or other exogenous changes, have been implemented in the model, a new counterfactual equilibrium is computed and the initial database is updated. Finally, the results are reported as changes in the updated database compared to the initial situation. Results may be presented in percentage changes or in levels. These include changes in output quantities, factor use and prices as well as overall summary indicators like changes in trade balance, consumer utility or regional welfare. Welfare measures are usually based on the underlying utility functions in the model. Although not without problems, the Compensating and Equivalent Variation measures developed by HICKS (1939) are widely used in AGE modeling (SHOVEN and WHALLEY 1992, p.123-128; HERTEL and TSIGAS 1997, p.35).

#### 2.1.3 Critical Issues in Applied General Equilibrium Modeling

Several difficulties arise with the construction of complex AGE models. First of all, while AGE models are very demanding with respect to the number of exogenous
parameters, empirical estimates of most elasticities are scarce and often contradictory or inappropriate for a specific model design. Of course, this generally reduces the reliability of model results. The potential of calibration procedures is often limited, when even the key parameters are not readily available. Moreover, the possibility of sensitivity analyses does not immediately alleviate this problem. Complex AGE models contain such a large number of parameters that a meaningful sensitivity analysis often seems not manageable in a reasonable time frame. However, recently there has been some progress in developing automated procedures for systematic sensitivity analysis in large models. The approach by ARNDT and PEARSON (1996) will be briefly discussed in Chapter 2.4.

Second, some of the key assumptions in many standard AGE models have been widely criticized. Full employment and perfect competition are the most striking examples (SHOVEN and WHALLEY 1992, p.5). Usually these assumptions are imposed in order to simplify a model. The possibility of unemployment would require the introduction of market inequalities which in turn requires advanced algorithms to solve the model. With regard to imperfect competition there is no unique theoretical approach, and hence there are various ways how to implement monopolistic or oligopolistic behavior realistically in an applied policy model. In any case, imperfect competition can be introduced into an AGE model, but it inflates the size of the model and the number of additional parameters tremendously (SWAMINATHAN and HERTEL 1996). This again adds to the above mentioned problem of parameter specification. Another important assumption refers to international factor movements, especially of capital. In most models regional factor endowments are fixed at initial levels. However, in the process of economic globalization capital becomes more and more mobile between regions which has important implications for the effects of national trade policy interventions. The existence of multinational firms and foreign direct investment are rarely taken into account in AGE models.<sup>3</sup>

A third issue which is neglected in neoclassical simulation models is the existence of sunk costs and path dependence in economic systems (BALMANN 1995). In many cases, certain rigidities, like investments in fixed assets, prevent economic agents from making

<sup>&</sup>lt;sup>3</sup> In the recent literature there are some approaches to AGE modeling of international capital mobility and accumulation that will be discussed in Section 2.4. For the impact of foreign direct investment in Central and Eastern European transition countries see LOTZE (1998).

their decisions purely based on relative marginal costs. This may lead to persistent market structures which change very slowly over time. Path dependence could play an important role, for example, in the analysis of restructuring processes in transition countries. However, as yet these issues have not been taken into account in AGE modeling.

A fourth critique of standard AGE analysis concerns the representation of policy instruments in the models. This is especially important for modeling agricultural and food policies, where the variety of instruments is vast. Specific real-world taxes and tariffs are often difficult to translate into a model-equivalent form due to different aggregation levels with respect to sectors and agents. Hence, "... for each tax there is substantial disagreement in the literature as to the appropriate treatment" (SHOVEN and WHALLEY 1992, p.5). In trade models, non-tariff barriers and quantitative restrictions often cause difficulties. Recent advancements in modeling techniques have tackled these issues (BACH and PEARSON 1996). However, aggregated multi-sector or AGE models have their limitations when farm specific policy measures are introduced, like upper limits for subsidy payments per individual farm. These policies can only be modeled consistently with farm-based sector models (BALMANN et al. 1998).

Finally, meaningful tests of AGE model specifications in a statistical sense are lacking. In the calibration procedure of an AGE model, a deterministic framework based on rigorous assumptions is constructed such as to reflect an artificial equilibrium situation which corresponds to a real economy at a single point in time. However, "... with enough flexibility in choosing the form of the deterministic model, one can always choose a model so as to fit the data exactly. Econometricians, who are more accustomed to thinking in terms of models whose economic structure is simple but whose statistical structure is complex (rather than vice versa), frequently find this a source of discomfort" (SHOVEN and WHALLEY 1992, p.6).

Having discussed the potential as well as certain weaknesses of AGE models in general, in the remainder of this chapter the theory and structure of the GTAP model is provided as a specific example.

## 2.2 Theory and Structure of the Global Trade Analysis Project Model

The Global Trade Analysis Project (GTAP) was established in 1992 at Purdue University, West Lafayette, USA. The main objectives of the project were to combine research efforts of many international experts in quantitative policy modeling and to lower entry costs for researchers who are willing to conduct economy-wide analyses of international economic issues, but who have not been involved in applied general equilibrium modeling before (HERTEL 1997, p.1.1). The start-up costs for model development, data collection and calibration are very high for complex multicommodity, multi-region models. Therefore, GTAP aims to provide a standard modeling framework and a common database for AGE analysis which gives researchers the opportunity to focus on policy implementation problems and further model development rather than spending too many resources on setting up the basic requirements.<sup>4</sup>

# 2.2.1 A Graphical Overview

Because the GTAP model is very complex, it may be useful to provide a graphical overview of the basic structure, before going into further detail of the model equations.<sup>5</sup> Figure 2.5 presents the basic value flows for one model region. For simplicity, there is no depreciation in this Figure, and government intervention in the form of taxes and subsidies is also omitted. At the top of Figure 2.5 is the so-called regional household which has a fixed endowment with primary factors of production, i.e. land, labor and capital. Without government intervention, the only source of income for the regional household is from sales of endowment factors to producers which yields factor payments in return. The regional household has an aggregate utility function which allocates regional income across three broad categories, i.e. private expenditure, government expenditure and savings. The most important advantage of the formulation of a regional household in an AGE model is the provision of an unambiguous indicator for overall regional welfare. As regional income rises, the regional utility function which will be discussed below takes not only changes in private expenditures, but also savings and government purchases into account (HERTEL and TSIGAS 1997, p.10).

<sup>&</sup>lt;sup>4</sup> An overview of GTAP can be found at the Internet site http://www.purdue.edu/gtap.

<sup>&</sup>lt;sup>5</sup> For a detailed graphical overview see BROCKMEIER (1996).



Figure 2.5: Value flows in an open economy model without government intervention

Source: Adapted from BROCKMEIER (1996).

Private households spend their income on domestic as well as imported goods. The same applies to the government household which demands domestic and imported commodities in order to produce public goods and government services. Producers<sup>6</sup> combine primary as well as intermediate inputs in order to satisfy this final demand. They also use imported intermediate inputs and supply export commodities to the rest of the world.<sup>7</sup> Bilateral exports and imports are distinguished by destination and source region. Moreover, imports are distributed among specific domestic user groups, i.e.

<sup>&</sup>lt;sup>6</sup> The terms producers and firms are used synonymously throughout this chapter.

<sup>&</sup>lt;sup>7</sup> The rest of the world can be disaggregated into various single regions. They are structured in the same way as described in Figure 2.5, but the details are omitted for simplicity.

private households, government and firms. This is especially important for the analysis of trade policy issues.

Finally, there are two global sectors in the model. First, there is a global bank which balances regional savings and investments and thus provides the so-called macroeconomic closure of the model. Producers, in addition to final commodities, also supply an artificial investment good, which is collected by the global bank and then distributed to regional households in the form of shares in a global portfolio, in order to satisfy their demand for savings. Second, there is a global transportation sector which accounts for the differences between *fob* export values and *cif* import values in international trade on a global scale (HERTEL and TSIGAS 1997, p.11).

# 2.2.2 Model Variables, Coefficients and Parameters

The structure of the GTAP model will be discussed by referring to Appendix A-2.1 where the readable text file of the standard model code is listed. The model code begins in Section A-2.1.1 with the definition of relevant files and sets. There are three types of files used in the modeling process: a data file with the base data in value terms, a parameter file with elasticity parameters, and a set file where various sets of commodities and regions are defined. There is a one-to-one relationship between sectors and commodities, i.e. each sector in the model produces only one good. Furthermore, there are three primary endowments, i.e. land, labor, and capital. Their initial levels are fixed for each region. By default, labor and capital are mobile endowments while land is sluggish, i.e. imperfectly mobile between sectors.

Following these initial statements, the model variables have to be defined. The GTAP database is formulated in value terms, e.g. the value of imports of a certain commodity from one region to another, or the value of a certain endowment used for the production of a certain commodity. Each of these value terms can be described by a *quantity variable* and a *price variable*. Quantities and prices are endogenously changed in the model which yields an updated value term after the model has been solved for a new equilibrium. In addition to quantity and price variables, there are *technical change variables* which can be implemented at various stages of the production technology.

Various taxes and subsidies are the *policy variables* in the model. They provide the linkages between market prices at various levels. For example, an output tax (*to*) can be implemented as a wedge between the market price and the price which the producer actually receives, the so-called agents' price in the GTAP terminology. Similarly, a tax or subsidy on primary inputs (*tf*) defines the difference between the input market price and the actual factor cost for the producer. Moreover, there are other tax instruments like source-specific import taxes and destination-specific export taxes available. A variable import levy can also be implemented by fixing the ratio between the world market and the domestic market price.

Furthermore, *value, income* and *utility variables* are necessary for calculating summary indicators which are based on the price and quantity changes resulting from a model run. Finally, there are several so-called *slack variables*. These are used in the model to change the closure rule for different modeling purposes. An AGE model has to be closed in a sense that all value flows have to be accounted for, i.e. in equilibrium there are no surpluses and profits. The model can be checked for consistency by applying Walras' law. Therefore, one market is dropped from the model formulation. In the standard case, this is the market for savings and investment. If all other markets are in equilibrium after the model has been solved, then the last market also has to be in equilibrium. This is checked by the endogenous variable walraslack<sup>8</sup> which has to be zero in a general equilibrium. The other slack variables are useful for partial equilibrium closure rules. For example, in certain cases one might want to look only at one country or region by creating a single-region general equilibrium model. This can be done in GTAP by fixing all trade linkages and keeping prices and income constant in all other regions, i.e. making them exogenous in the model. However, simply making certain variables exogenous would cause the solution algorithm to break down. The number of equations and endogenous variables would no longer be the same and, hence, the model could not be solved. This can be circumvented by making the relevant price variables exogenous, and at the same time making the corresponding slack variables endogenous. Thus, prices and quantities in certain regions can be kept constant, but the number of endogenous variables in the model remains the same.

<sup>&</sup>lt;sup>8</sup> See the section on "slack variables" in Appendix A-2.1.1.

After the variables have been defined, the base data have to be read by the modeling software. This is described in Section A-2.1.2 in the Appendix. Since the model is formulated in percentage changes, the value terms from the database enter the model as coefficients.<sup>9</sup> Value terms in the database are defined at three price levels: agents' prices, market prices and world prices. The difference, for example, between the value of output at agents' prices and market prices is defined by the level of output taxes or subsidies. Likewise, border intervention measures account for any difference between the value of exports, or imports, at domestic market prices and world prices.

The links between the values of output, government intervention, international transportation, and final consumption in the model are illustrated in Figure 2.6.

Domestic market in region "r"	Value of output at agents' prices		
	+ Output taxes/subsidies		
	= Value of output at market price		
	$\Rightarrow$ Domestic sales, exports, and transportation		
	Value of exports at market prices		
	+ Export taxes/subsidies		
World market	= Value of exports at world prices ( <i>fob</i> )		
	+ Value of international transportation		
	= Value of imports at world prices ( <i>cif</i> )		
Domestic market in region "s"	+ Import taxes/subsidies		
	= Value of imports at market prices		
	⇒ Import purchases of private households, government and firms		

Figure 2.6: Distribution of sales to regional markets

Source: Adapted from HERTEL and TSIGAS (1997, p.46).

Starting with the value of output at agents' prices in region r, output taxes or subsidies can be added which yields domestic output at market prices. Part of this is exported, and by adding export taxes or subsidies, the value of exports at *fob* world prices can be derived. International transportation provides the link to the corresponding import region s where imports are valued at *cif* world prices. Adding import taxes or subsidies yields the value of imports at domestic market prices in region s. Finally, these imports are distributed among private household consumption, government purchases, and firms' intermediate input use. In a similar way, all sales, purchases and government

<sup>&</sup>lt;sup>9</sup> The relationship between the value terms and the underlying quantities and prices will be discussed in more detail in Section 2.2.3.

interventions can be traced in the model. In the case of an input tax or subsidy on land, labor, or capital, there would be a difference between the value of input use at agents' prices and market prices.

After the value coefficients have been read from the data file, parameters defining substitution and income elasticities have to be read into the model from the parameter file. Finally, having set up the basic information from the database, the model calculates a variety of additional value and share coefficients which simplify the formulation of later calculations.<sup>10</sup>

# 2.2.3 Model Equations

The model equations, which are listed in Section A-2.1.3 in the Appendix, define the behavior of model agents as well as market clearing conditions, based on the theoretical foundation of the model. While the model is principally non-linear in the levels of the variables, it is nevertheless formulated in terms of percentage changes of the endogenous variables. This yields a linear form of the model which then can be solved for an equilibrium by using linear approximation methods.

Using Equation 1 in the Appendix Section A-2.1.3 as an example, at this point it will be explained how the non-linear model can be transformed into a linearized representation (HERTEL and TSIGAS 1997, p.15-20; HARRISON and PEARSON 1996, p.3.3). Equation 1 can be derived starting with the market clearing condition for tradable commodity i in region r:

(1) 
$$VOM(i,r) = VDM(i,r) + VST(i,r) + \sum_{s} VXMD(i,r,s)$$
,

with: VOM(i,r) = output of commodity i in region r valued at market prices
VDM(i,r) = domestic sales of commodity i in region r valued at market prices
VST(i,r) = exports of commodity i from region r for transportation valued at market prices
VXMD(i,r,s) = exports of commodity i from region r to region s valued at market prices.

<sup>&</sup>lt;sup>10</sup> These derivatives from the base data are not stored directly in the database in order to avoid redundant information (see Section A-2.1.2 in the Appendix).

This can be rewritten in terms of the corresponding quantities and a common domestic market price PM for *i* in region *r*:

(2) 
$$PM(i,r) \cdot QO(i,r) = PM(i,r,) \cdot [QDS(i,r) + QST(i,r) + \sum_{s} QXS(i,r,s)],$$

with: QO(i,r) = output quantity of commodity *i* in region *r*  QDS(i,r) = domestic sales of commodity *i* in region *r*  QST(i,r) = export quantity of commodity *i* from region *r* for transportation QXS(i,r,s) = export quantity of commodity *i* from region *r* to region *s*.

Dividing through by PM(i,r) yields the market clearing condition in quantities:

(3) 
$$QO(i,r) = QDS(i,r) + QST(i,r) + \sum_{s} QXS(i,r,s).$$

In a similar way, any market clearing condition in quantities can be converted into value terms by multiplying through by a *common* price. Hence, only value terms are required in the database, which also simplifies the problem of model calibration (HERTEL and TSIGAS 1997, p.16).

However, the behavioral relationships in the model are more conveniently written not in value terms, but in *percentage changes* of prices and quantities.<sup>11</sup> The non-linear formulation of the model in value level terms can be transferred into percentage changes by totally differentiating the values in the following way:

(4) 
$$\frac{dV}{V} = \frac{d(PQ)}{PQ} = \frac{dP}{PQ} \cdot Q + \frac{dQ}{PQ} \cdot P = p + q ,$$

with: V = value term

P = price level

- Q = quantity level
- p = percentage change in price
- q = percentage change in quantity.

Linearization of the market clearing condition (3) involves total differentiation which yields a linear combination of appropriately weighted price and quantity changes:

(5) 
$$QO(i,r) \cdot qo(i,r) = QDS(i,r) \cdot qds(i,r) + QST(i,r) \cdot qst(i,r) + \sum_{s} QXS(i,r,s) \cdot qxs(i,r,s)$$

<sup>&</sup>lt;sup>11</sup>In addition, percentage changes are usually also the preferred output from the model exercises.

where the lower case variables are again percentage changes. Multiplying (5) on both sides by PM(i,r) yields the following equation:

(6) 
$$VOM(i,r) \cdot qo(i,r) = VDM(i,r) \cdot qds(i,r)$$
  
+  $VST(i,r) \cdot qst(i,r)$   
+  $\sum_{s} VXMD(i,r,s) \cdot qxs(i,r,s)$ .

This is the main part of Equation 1 in the model code described in Section A-2.1.3.<sup>12</sup> In addition, there is also the term  $VOM(i,r) \cdot tradslack(i,r)$  included in the equation. The slack variable is usually exogenous and zero, but it can be endogenized in the case of a partial equilibrium closure of the model.

In the linearized form of the equations, initial value terms taken from the database enter the model as constant coefficients. In a model run, percentage changes in endogenous prices and quantities are derived, and then the value terms are updated according to the update statements given for each coefficient in the model code. The updated value terms are stored in an updated data file which can be used for subsequent modeling purposes. Several approximation methods are available for solving a non-linear model via its linearized representation (HARRISON and PEARSON 1996, Chapter 2.5).

The first group of equations in the model code includes market clearing conditions for all traded goods, for mobile and imperfectly mobile endowments, and for private household expenditures. Furthermore, price linkage equations account for the differences in prices at various market levels caused by government intervention. All policy variables are called taxes in the model code, but in fact they represent taxes as well as subsidies depending on their sign.

## Behavioral equations for producers

The second group of equations contains the behavioral restrictions for producers imposed by neoclassical economic theory. Figure 2.7 shows the so-called technology tree which illustrates a separable, constant-returns-to-scale production technology.<sup>13</sup>

<sup>&</sup>lt;sup>12</sup>The summation sign in the model code is written as "sum[s, REG, VXMD(i,r,s)  $\cdot$  qxs(i,r,s)]".

<sup>&</sup>lt;sup>13</sup>There are many other possible representations of production technologies in AGE models, according to specific modeling requirements and data availability (SHOVEN and WHALLEY 1992, p.94-100; SADOULET and DE JANVRY 1995, p.349-356). In the GTAP model, the current specification has been chosen, among other reasons, to facilitate the calibration of the model to a global database.



Figure 2.7: The production technology tree in the GTAP model

Source: Adapted from HERTEL and TSIGAS (1997, p.56).

This production technology has a so-called nested structure. Based on certain assumptions about separability in production, firms are making their production decisions in the model in several independent steps. The separate nests are combined through elasticities of substitution. On the left-hand side of the production tree is the value-added nest, i.e. firms use primary inputs (*qfe*) which are combined in a constantelasticity-of-substitution (CES) function. The elasticity of substitution is denoted  $\sigma_{va}$ . Firms also use intermediate inputs, some of which are domestically produced (*qfd*) and some of which are imported (*qfm*). They are combined in a CES function with  $\sigma_d$  as the elasticity parameter. Imported intermediate inputs are sourced from specific regions through bilateral trade flows (*qxs*), which is done according to the Armington assumption (ARMINGTON 1969). Again, a CES function is used with  $\sigma_m$  as the elasticity of substitution between imports from various regions. Finally, at the top of the production tree, the primary input composite and intermediate composite are joined in fixed proportions via a Leontief function, i.e.  $\sigma$  equals zero, to produce final output *qo*. On each level of this production tree a variable for implementing technical change is also available. Technical change in the GTAP model can be land, labor or capital saving, intermediate input saving, or overall Hicks-neutral.

The major advantage of the nested structure is that it significantly reduces the number of required model parameters and thus simplifies the calibration procedure. However, the chosen production technology is very restrictive in various directions, e.g. there is no substitutability between primary inputs and intermediates, which is certainly unrealistic. Moreover, the Armington approach to modeling international trade has been widely criticized, because the degree of product differentiation by region is given exogenous and not subject to the model exercise. Still, the use of the Armington assumption can be justified, because it is able to capture to some degree intra-industry trade, i.e. trade flows between regions in both directions for similar products (HERTEL and TSIGAS 1997, p.21-22).

There are two types of equations for each nest in the production tree. The first describes substitution between inputs within the nest. The second type is the composite price equation which determines the unit cost for the composite good produced by that branch. This composite price enters the next higher nest and determines the demand for this composite good. Both types of equations can be derived by starting with the definition of the elasticity of substitution (HERTEL and TSIGAS 1997, p.22-24). For illustrative purposes the example of two input goods and their inverse price ratio is shown here:

$$\sigma \equiv \frac{d(Q_1/Q_2)}{d(P_2/P_1)} \cdot \frac{P_2/P_1}{Q_1/Q_2} ,$$

with:  $\sigma$  = elasticity of substitution  $Q_1, Q_2$  = quantity levels  $P_1, P_2$  = price levels.

From this, the following equations can be derived where prices and quantities are now expressed in percentage change terms (HERTEL and TSIGAS 1997, p.22-24):

Price equation:  $p = \theta_1 p_1 + (1 - \theta_1) p_2$ 

Quantity equation:  $q_1 = \sigma(p - p_1) + q$ ,

with: *p* = price for *composite* input good

$p_1, p_2$	= prices for primary inputs
$\theta_l$	= cost share of primary input 1
q	= quantity of <i>composite</i> input good
$q_1$	= quantity of primary input 1

The first equation defines a weighted price p for the *composite* input good q. The second equation defines a firm's derived input demand for good  $q_1$ , which is decomposed into two components. The first is the substitution effect, i.e. the product of the constant elasticity of substitution and the percentage change in the ratio of the composite price p to input price  $p_1$ . The second component is the expansion effect, i.e. the percentage change in the output quantity of the *composite* good q. This simply assures an equiproportionate relationship between output and input, related to the assumption of constant returns to scale.<sup>14</sup>

The mobility of sluggish endowments, e.g. land, between sectors is governed by a constant-elasticity-of-transformation (CET) supply function which is analogous to a CES function on the demand side. As the elasticity of transformation increases, these endowments become more mobile between sectors. A consequence of imperfect factor mobility, in contrast to the perfect mobility case, are different factor prices for different sectors. If factor use is prohibited from full adjustment, factor prices have to differ in order to maintain a general equilibrium.<sup>15</sup>

# Behavioral equations for households

The third group of equations define the behavior of households in the model. The overall regional household's behavior is determined by an aggregate Cobb-Douglas utility function which is specified over three categories: private consumption, government purchases and savings (Figure 2.5). Although the allocation of savings is an intertemporal maximization problem, it is possible, by a proper specification of the utility function, to represent savings in a comparative static model (HERTEL and TSIGAS 1997, p.25). In a macroeconomic sense the model is savings-driven, as the share of regional income spent on savings is constant in the Cobb-Douglas function, and the level of regional investment has to adjust accordingly.

<sup>&</sup>lt;sup>14</sup>Equation 30 to 36 in the model code (Section A-2.1.3) represent exactly these two relationships for the various nests shown in Figure 2.7. At each stage, the relevant technical change variable are added to the equations.

<sup>&</sup>lt;sup>15</sup>Equations 50 and 51 in the model code determine prices and quantities for sluggish endowments.

In order to derive a regional welfare measure, certain assumptions have to be made about the level of government purchases which are spent on the provision of public goods and services. The above mentioned regional utility function implies that preferences for public goods are separable from preferences for private goods, and the utility for public goods is identical across private households in the region. Furthermore, it is assumed that the initial level of public goods provided in each region is optimal (HERTEL and TSIGAS 1997, p.25). However, this assumption can be changed by exogenously fixing the level of government purchases. In that case, private household consumption alone has to provide full adjustment to changes in the regional economy. The regional Cobb-Douglas utility function is specified in a per-capita form with fixed expenditure shares on the three types of regional expenditures. Hence, in the case of a simulation period over several years, the population growth rate, represented by the variable pop(r), has to be taken into account for the calculation of regional utility.

Government spending on final commodities is allocated by another Cobb-Douglas function. First, expenditures are distributed in fixed shares among domestic and imported composite goods, and then imports are sourced by regions via the Armington parameters. Private household demand is treated differently, and this is a specific feature of the AGE model developed by GTAP. Private demand is clearly nonhomothetic in nature, i.e. the expenditure shares of various commodities change as the level of income changes. This is important in a global trade model, where per-capita income levels differ significantly between regions. Moreover, a welfare increase, e.g. through trade liberalization, is likely to change the structure of private consumption. In the GTAP model, for the private household utility function the so-called constant difference of elasticities (CDE) form has been chosen. It is more flexible than the nonhomothetic CES form, but it still can be calibrated to existing information on income and own-price elasticities of demand (HERTEL and TSIGAS 1997, p.26-27; HERTEL et al. 1991). The parameters of the CDE function are initially calibrated to replicate a prespecified vector of income and own-price elasticities. However, these elasticities are generally not constant, they rather vary with different expenditure shares and relative

prices. Hence, the elasticity values have to be updated with each iteration of the model.<sup>16</sup>

### Savings and investment – the macroeconomic closure

The next group of equations covers a crucial area in any AGE model, the so-called macroeconomic closure. In order to close the economic system of resource flows as shown in the social accounting matrix (Figure 2.3) and the stylized GTAP model (Figure 2.5), a link between savings and investments has to be established in the model. GTAP does not account for any macroeconomic and monetary policies, which are usually the driving forces behind aggregate investment. In fact, there is no "money" in the model, as it is rather concerned with real resource flows and re-allocation effects caused by trade policy interventions or other exogenous shocks. However, the allocation of investment across regions has implications on production and trade through its effects on final demand. Because there is no intertemporal mechanism for the determination of investment in the model, the closure in a macroeconomic sense has to be provided in another way.

There are various solutions to this problem (DEWATRIPONT and MICHEL 1987; SHOVEN and WHALLEY 1992, p.230-240; SADOULET and DE JANVRY 1995, p.354-355; HERTEL and TSIGAS 1997, p.28-34). As mentioned above, like many other models, the GTAP model is savings-driven. The amount of savings is determined as a certain share of regional income, and investment has to adjust accordingly. One possibility in a multiregion model is to achieve the savings-investment equilibrium on a regional basis. The current account balance of each region can be fixed, and the difference between regional savings and investment always has to be equal to the current account surplus or deficit. However, the GTAP model also allows for a global closure. This is facilitated by a global bank as shown in Figure 2.5. In addition to the production of traded commodities, each sector in each region also produces a certain amount of an artificial, homogeneous investment good, called capital goods.<sup>17</sup> The production of capital goods is modeled in the same way as the production of traded goods already discussed. However, only intermediate inputs, but no primary factors, are used in the production

<sup>&</sup>lt;sup>16</sup>The formulae for these calculations are given in section A-2.1.2. HUFF et al. (1997) provide a detailed discussion on the CDE function. Private household behavior in the model is determined by Equations 45 to 49 in Section A-2.1.3.

<sup>&</sup>lt;sup>17</sup>The corresponding model variable is called *cgds*, with a respective price variable *psave*.

function for capital goods. The global bank purchases these investments goods in all regions and sells them to regional households in order to satisfy their demand for savings commodities. Thus, the global bank provides a link between regional savings and investment on a global scale. The price for the investment good is the numeraire for all other prices in the model. However, the market equilibrium for capital goods is not enforced by a market clearing condition. This market is omitted from the equations, because it is used for checking Walras' law as mentioned earlier.

The GTAP model provides two alternative mechanisms for allocating investment across regions, which are explained in more detail in HERTEL and TSIGAS (1997, p.30-34). Under the first option, the regional rate of return on capital is equal across all regions. This is to say that the shares of regional investment in the global portfolio have to adjust in order to achieve a common global rate of return on capital. Under the second option, the regional composition of the global capital stock remains unchanged, and the region-specific rates of return have to adjust accordingly. The choice between the two options has to be made according to the specific modeling exercise. As long as a certain scenario is short-run and affects only a relatively small part of the global economy, it seems realistic to use the second option and keep the regional shares in the global capital stock constant. Under certain long-run scenarios, the choice of the investment allocation mechanism can significantly alter the size of international trade flows.

## **Global Transportation**

The second global activity, apart from the global bank, is the service of international transportation which links exports from one region to imports of another region, and thus accounts for differences in the corresponding values at *fob* and *cif* prices. Transportation services are provided by a Cobb-Douglas production function which demands certain exports from all regions as inputs. Due to missing data these exports are simply combined into a composite international "transport good" with a common price. Again, the transportation activity is described by a price equation and a quantity equation as discussed with respect to the production technology. Commodity and route specific technical change in international transportation services can also be specified in the model (HERTEL and TSIGAS 1997, p.34).

## 2.2.4 Summary Indicators and Results

The final group of the model equations provides a number of summary indicators which are actually not necessary for computing an equilibrium, but which are useful for presenting the results of a model exercise. The basic results of a model run would consist of percentage changes in all the endogenous variables discussed earlier. In addition, several domestic price indices can be calculated, e.g. the regional terms of trade or the price index for private household expenditure. Then there is the percentage change in the value of GDP, which can also be broken down into a price and a quantity component. The overall change in welfare is calculated as the Hicksian measure of Equivalent Variation (EV) for each region and for the world as a whole.<sup>18</sup> The welldefined utility function of the regional household allows this calculation by multiplying the percentage change in overall regional utility by the initial level of regional income. Welfare changes are expressed in million US\$, valued in the base year, i.e. 1992 in version 3 of the GTAP database. The change in world welfare is simply the sum of all regional welfare changes. It is important to note that the calculation of the Equivalent Variation is only valid in the case of a general equilibrium model closure. Once a partial equilibrium closure of any kind is chosen by endogenizing certain slack variables, the EV values might not be consistent any more and should be interpreted very carefully.

With respect to international trade there are several useful value indices as well as related price and quantity indices. Probably the most important price index in a global trade model is the world market price index for traded commodities. It is calculated as the weighted average of regional export *fob* price indices, using the value of regional production at *fob* prices as weights. Finally, the changes in regional commodity-specific trade balances and the change in the regional current account are provided. These are both given in value terms, i.e. in million 1992 US\$.

This concludes the discussion of the standard GTAP model structure and the model code. The model is implemented and solved using the General Equilibrium Modeling Package (GEMPACK).<sup>19</sup> A typical modeling exercise would imply the following steps. First, the data and parameter files have to be specified. Then, the closure rules have to

<sup>&</sup>lt;sup>18</sup>See JUST et al. (1982, Chapter 6) for a derivation of the Equivalent Variation.

<sup>&</sup>lt;sup>19</sup>A detailed description of GEMPACK is given by HARRISON and PEARSON (1996). They also discuss various solution algorithms for large models. The internet site of GEMPACK can found at http://www.monash.edu.au/policy/gempack.htm.

be defined, and it has to be determined which of the variables are endogenous and which are exogenous in a certain application. Finally, the exogenous shocks to the initial equilibrium have to be listed. Shocks can be changes in policy intervention through taxes and subsidies, technical change of various kinds, population growth, or other endowment shocks.

## 2.3 The Global Trade Analysis Project Database

One of the most important achievements of the Global Trade Analysis Project is the construction of a global database for AGE modeling. This is an on-going project and the database is continuously improved and up-dated. It contains information based on individual countries' input-output tables, bilateral commodity trade between regions as well as data on international transportation and protection (HERTEL 1997). Information for the database is provided by various national and international organizations, including the World Bank, the World Trade Organization (WTO), the United Nations Conference on Trade and Development (UNCTAD), the Organization for Economic Cooperation and Development (OECD), the European Commission, and the Economic Research Service (ERS) of the United States Department of Agriculture (USDA). In addition, many individual researchers have provided data on specific regions of their interest. Thus, GTAP explores the comparative advantage of a wide range of regional experts in the world economy. The global database also provides an opportunity for comparing the potential of various AGE models on the basis on a common data set. This is important, as differing results from different models are often explained by the fact that different data sets were used. This might not be true in all cases.

The complete database as well as the procedures for harmonizing data from many different international sources are fully documented in MCDOUGALL (1997). Table 2.1 shows the complete list of regions and sectors included in version 3 of the GTAP database, which covers the global economy in the reference year 1992.<sup>20,21</sup>

<sup>&</sup>lt;sup>20</sup>In summer 1998 version 4 of the GTAP database has been released. It has 1995 as a new reference year and is extended to 50 sectors and 45 regions. Among other changes, labor has been split into "skilled" and "unskilled" labor, and "natural resources" have been introduced as a new primary endowment. For more information see the GTAP internet site at http://www.agecon.purdue.edu/gtap.

<sup>&</sup>lt;sup>21</sup>Usually, for specific model applications a smaller aggregation of the original database is used. GTAP provides the opportunity to aggregate certain regions and sectors into larger groups according to the focus of a certain modeling exercise.

Model sectors		Model regions <sup>a</sup>		
1	Paddy rice	1	Australia	
2	Wheat	2	New Zealand	
3	Other grains	3	Japan	
4	Non-grain crops	4	Korea	
5	Wool	5	Indonesia	
6	Other livestock	6	Malaysia	
7	Forestry	7	Philippines	
8	Fisheries	8	Singapore	
9	Coal	9	Thailand	
10	Oil	10	China	
11	Gas	11	Hong Kong	
12	Other minerals	12	Taiwan	
13	Processed rice	13	India	
14	Meat products	14	Rest of South Asia	
15	Milk products	15	Canada	
16	Other food products	16	United States	
17	Beverages and tobacco	17	Mexico	
18	Textiles	18	Central America and the Caribbean	
19	Wearing apparel	19	Argentina	
20	Leather, etc.	20	Brazil	
21	Lumber	21	Chile	
22	Pulp, paper, etc.	22	Rest of South America	
23	Petroleum and coal	23	European Union (EU-12)	
24	Chemicals, rubbers, and plastics	24	Austria, Finland, Sweden (EU-3)	
25	Non-metallic minerals	25	EFTA (Iceland, Norway, Switzerland)	
26	Primary ferrous metals	26	Central European Countries (CEC-7) <sup>b</sup>	
27	Non-ferrous metals	27	Former Soviet Union	
28	Fabricated metal products	28	Middle East and North Africa	
29	Transport industries	29	Sub-Saharan Africa	
30	Machinery and equipment	30	Rest of the World	
31	Other manufacturing			
32	Electricity, water, and gas			
33	Construction			
34	Trade and transport			
35	Other savings (private)			
36	Other services (government)			
37	Ownership of dwellings			

**Table 2.1:** Sectors and regions in the GTAP database (version 3)

 <sup>a</sup> For details on the composite regions see McDOUGALL (1997, Chapter 8).
 <sup>b</sup> These are Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia. The group is called "Central European Associates" (CEA) in the GTAP documentation.

Source: MCDOUGALL (1997).

Harmonization of data and other information from different international sources is a critical issue in the development of a global database. National input-output data, trade flows and estimates of government intervention heavily differ depending on the reporting institution. Problems occur with respect to different base years, different commodity and country aggregations, and simply inconsistencies and statistical errors. In order to achieve a database which represents a global equilibrium for a certain reference year, all these problems have to be overcome. Clearly, the outcome can only be a best guess based on the information available at a certain point in time. Nevertheless, the broad cooperation within the Global Trade Analysis Project assures that for most countries and commodities probably the best available data have been used. In any case, the current state of the database provides a sound basis for future improvements. Some of the data problems, with a special focus on the EU and the Central and Eastern European countries, will be briefly discussed in the following.

## National input-output data

National input-output tables or SAMs are often difficult to obtain. Even for most industrialized countries they are only published at long intervals. Country tables usually differ with respect to reference years and sector disaggregation such that they are often not comparable. For many developing as well as transition countries the problem is even worse, as in many cases there exists no up-to-date information at all (WAHL and YU 1997).

The collection and preparation of the regional data for the EU in GTAP is described in BROCKMEIER (1997). Input-output tables have been collected from national statistical offices and Eurostat, the statistical office of the EU. Although Austria, Finland and Sweden have already joined the EU, they are kept as a separate region (EU-3) to allow for analyses of European integration issues with the GTAP model. The member countries' information differs in the base years and sector aggregations. The most recent national input-output tables are from 1987 in the Netherlands and Luxembourg, while the other countries only have complete data on 1985 (BROCKMEIER 1997, p.16.2.4). The sector disaggregation is broader in most EU countries (59 sectors) than in the GTAP database (37 sectors). Hence, many sectors can be aggregated without problems. However, agriculture, forestry, and fishery products are combined into one sector in the EU classification. For their disaggregation, additional information from the Sectoral

Production and Income Model of Agriculture for the European Union (SPEL) has been used (EUROSTAT 1995). The input-output table for the EU-3 region was constructed from national statistics of the three recent EU members (KERKELA 1997). For input-output tables with an inappropriate base year or sector disaggregation, a statistical fitting procedure has been applied to update and modify the original data according to more recent macroeconomic information (MCDOUGALL and HERTEL 1997).

The biggest problems concerning domestic data occur, of course, in the Central European countries and the Former Soviet Union (WAHL and YU 1997). Most of the data used in GTAP were provided by the World Bank. However, all the original input-output tables are out-dated and have their base years between 1987 and 1989, i.e. still in socialist times. Moreover, the sectoral coverage is generally not in accordance with the GTAP disaggregation. Only for Hungary there was some additional recent information available. Hence, an extensive revision of the input-output tables for these regions had to be undertaken in which average values from other countries or regions at a comparable level of development were used. The strategy was to "retain the final demand structure of the contributed tables – that is, the commodity composition of consumption, exports and investment – but to replace the industry cost structures. The new cost structures ... are, in effect, averaged over many regions. ... This should be borne in mind in any application of GTAP data for Eastern European issues" (WAHL and YU 1997, p.16.4.17-18).

## Bilateral trade flows

The establishment of a consistent database on merchandise trade flows poses a different challenge than for other data components in the GTAP database. "The problem is less a matter of finding scarce data and more a matter of resolving inconsistent data. This is because one country's exports are also another country's imports, and imports and exports are reported by both partners. This reporting arrangement produces two trade records representing the same trade flows. Large discrepancies can be found when comparing a country's exports flows with its corresponding partners' import flows. Discrepancies in bilateral trade statistics pose a problem for use in the GTAP database" (GEHLHAR 1997, p.11.1). In order to make trade data useful for a global AGE model, they have to be balanced in the initial situation. This means, the value of imports at *cif* prices for a certain commodity and region, minus the value of transportation services,

has to be equal to the value of exports at *fob* prices at the border of the trading partners. The reliability of the structure of trade is important for the credibility of the AGE model results. Various methods can be applied to balance all the bilateral trade flows in the database (GEHLHAR 1997). The common objective is to generate the most reliable set of trade flows possible from the existing reported trade data. Of course, neither of the applied methods can be a substitute for insufficient source data.

The main sources of bilateral trade data are the COMTRADE database by the United Nations (UN), the World Bank's World Tables, the balance-of-payments and financial statistics by the International Monetary Fund (IMF), the FAOSTAT database by the Food and Agriculture Organization (FAO) of the UN, and the UNCTAD database. One side effect of establishing the GTAP database has been a quality assessment of the "raw ingredients found in bilateral trade statistics" (GEHLHAR 1997, p.11.2). The results can be summarized as follows. In many individual cases large discrepancies in reported trade flows can be found. However, although 73 percent of the *number* of bilateral trade flows seem to be unreliable, these transactions contribute only 2 percent of the total *value* of trade in the database. On the other hand, over 75 percent of the value of individual transactions are reported with a discrepancy of less than 25 percent (GEHLHAR 1997, p.11.20). Like the other contributions to the GTAP database, collection and derivation of reliable trade data is an on-going process.

# Agricultural protection data

The outcome of any modeling exercises on regional integration and trade liberalization in agriculture and food products crucially depends on the initial protection levels in the database. It is a very demanding task to define unambiguous protection levels on a global scale, especially in agriculture and food sectors where an abundance of protection measures prevails in addition to simple import tariffs and export subsidies. The protection data in the GTAP database where mainly contributed by the World Bank and the WTO (REINCKE 1997; INGCO 1997; HUFF 1997).

The GATT Uruguay Round for the first time established international rules for trade in agricultural products. Important regulations agreed upon in the UR were the "tariffication" of non-tariff barriers (NTBs) and the introduction of bindings on the value and volumes of existing export subsidies. Since all participating countries had to

submit detailed descriptions of their initial protection levels, this was a unique opportunity to collect comparable agricultural protection data on a global scale (INGCO 1997, p.14.1). Of course, the UR results were not without problems, as many countries applied a so-called "dirty" tariffication. They took advantage of the difference in protection levels between the UR base period of 1986-88 and the actual levels at the end of the negotiations, which enabled them to increase their tariff bindings. For example, the EU and the countries in the European Free Trade Agreement (EFTA) set their post-UR tariff equivalents for "sensitive" products like dairy, sugar and grains significantly higher than their actual rates of protection in 1986-88.

Nevertheless, the UR results were used to establish two sets of protection data in version 3 of the GTAP database, pre-UR and post-UR protection levels. This facilitates the implementation of UR issues in the GTAP model. How various NTBs were converted into tariff equivalents is discussed in detail in INGCO (1997, p.14.10). For the use in the GTAP database all the protection measures had to be included in either of three categories: the difference between the value of imports at *cif* prices and domestic market prices (import protection level), the difference between the value of exports at domestic market prices and *fob* prices (export intervention level), and the difference between the value of domestic support level).<sup>22</sup> These differences only define the initial protection levels in the database in the form of tax or tariff equivalents. However, starting from these levels, other policy measures like quantitative restrictions or variable levies can be implemented if required for any policy simulation.<sup>23</sup>

## Elasticity parameters

As discussed earlier, the behavioral parameters in the GTAP model include elasticities of substitution between imported goods by source region, i.e. Armington elasticities, factor substitution elasticities, factor transformation elasticities, investment parameters, and consumer demand elasticities (DIMARANAN et al. 1997). For many of these parameters external estimates or values from other AGE models have been used in the GTAP database. Armington and factor substitution elasticities have been mainly taken from the Australian SALTER model (JOMINI et al. 1991). These were derived from a

<sup>&</sup>lt;sup>22</sup>See the GTAP model structure on policy variables discussed earlier (Section 2.2.2).

<sup>&</sup>lt;sup>23</sup>Quantitative restrictions will be briefly discussed in Section 2.4 below.

review of international cross-section studies covering a wide range of countries and industries.

The parameters for the CDE demand functions of private households had to be calibrated to empirical estimates of income and price elasticities of demand. Income elasticities were taken from the World Food Model of the FAO (1993) as well as cross-country studies by THEIL et al. (1989), CHERN and WANG (1994), ZHI and KINSEY (1994), and FAN et al. (1995). In most cases, these studies had a different commodity disaggregation which had to be mapped to the GTAP structure of regions and commodities. With respect to price elasticities of demand there is much less information available in the literature. Using the available information on income elasticities, the values for own-price elasticities of demand were computed following a procedure developed in ZEITSCH et al. (1991). The calculated elasticity values are presented and discussed in DIMARANAN et al. (1997).

Reliable elasticity parameters are very difficult to obtain which is a problem for any empirical modeling project. Statistical estimation of elasticities is very demanding in terms of time and data requirements. At the same time, it is not a very rewarding activity any more in terms of methodological development. Consequently, not many researchers are actually undertaking broad-based empirical studies on elasticities. Moreover, in those cases where parameters are actually available for the use in simulation models, they are often fairly specific with respect to the regions, commodities or time period under consideration. This makes it difficult to implement them directly in an AGE model.

# 2.4 Recent Extensions to the Standard Applied General Equilibrium Model

In the recent literature on AGE modeling, several approaches for extending the standard modeling framework have been presented. Some possible extensions will be discussed in the following, i.e. systematic sensitivity analysis, welfare decomposition, implementation of quantitative restrictions, the introduction of imperfect competition, and more dynamic aspects like international capital mobility and accumulation.

### Systematic sensitivity analysis

Results from any empirical modeling exercise are critically dependent on exogenous variables and parameters used in the simulations. As already discussed, especially in complex AGE models many parameters are not known with certainty or even missing altogether. One approach to solve this problem is sensitivity analysis with respect to key exogenous variables, behavioral parameters, or policy interventions. However, sensitivity analysis in large models is usually ad hoc, as a more or less arbitrary set of parameters has to be chosen for the investigation (ARNDT 1996, p.1). This method is clearly unsystematic and provides little insight into the overall robustness of a model.

The core of the problem with unreliable model results is the mathematical fact that, for non-linear functions, the expected value *E* of a given function *H* is generally not equal to the value of the function evaluated at the expected value of an exogenous variable *a*, i.e.  $E[H(a)] \neq H(E[a])$ . This implies that, if a complex model is only solved once using mean values of uncertain parameters, the deterministic results may be a poor approximation of the mean results (ARNDT 1996, p.3). One solution to this problem would consist of an extensive Monte Carlo analysis, where the model runs would be repeated sufficiently often with a variety of parameter sets. However, for large multiregion AGE models this becomes impractical under normal time constraints.<sup>24</sup>

Another approach to sensitivity analysis is the so-called Gaussian Quadrature (GQ). In the GQ method, uncertain parameters and variables are described by a statistical density function. Consequently, the outputs of the GQ method are estimates of means and standard deviations of model results. In order to reduce the number of evaluations, a numerical approximation of the integral of the density function has to be applied. The special feature of GQ is the way how the weights are assigned in the numerical approximation to the integral of the density function. It can be shown that the outputs from this method, if applied to the GTAP model, are generally good approximations of means of model results and their associated standard deviations. They also provide valuable insights into the robustness of model results. On the other hand, GQ is applicable even under normal time and other resource constraints (ARNDT 1996; ARNDT and PEARSON 1996).

<sup>&</sup>lt;sup>24</sup>As an example, for sufficient confidence in the Monte Carlo results several thousand repetitions are necessary. If a solution run of the GTAP model took five minutes, which is not unusual, 1000 Monte Carlo repetitions would take about 3.5 days (ARNDT 1996, p.1).

# Welfare decomposition

In the standard GTAP model, as discussed earlier, the regional Equivalent Variation is used as an indicator of the overall welfare effect which may be caused by a policy change or any other shock to the initial equilibrium. The model code can be enhanced by adding a facility for decomposing the total welfare change into several components which are related to certain policy instruments or specific quantity and price changes (HUFF and HERTEL 1996). By using this application, the interpretation of model results becomes much more detailed, as direct and indirect effects of certain taxes can be easily evaluated and linked to the relevant quantity changes in various endowments and commodities.

To give some examples, the total welfare effect for each model region can be broken down into the overall change in allocative efficiency and the terms-of-trade effect. Then, the regional change in allocative efficiency can be assigned to the individual sectors. Moreover, the allocative efficiency effects can be related to specific tax instruments, i.e. taxes on outputs, inputs, or international trade flows. Finally, the contribution of an import tariff to the regional change in allocative efficiency can be further broken down to the various sectors (HUFF and HERTEL 1996, p.19-20). Hence, the facility for welfare decomposition enables the modeler to identify the share of any individual economic transaction in the total welfare results of a simulation run. Moreover, the method is not specific to the GTAP model. With the necessary modifications, it can be used in other AGE models as well.

# Quantitative restrictions

Standard policy instruments in the GTAP model include ad valorem taxes and tariffs at various levels of the production or demand functions as discussed in Section 2.2.2. However, quantitative restrictions, i.e. quotas, on production and trade have become important non-tariff barriers to international trade, especially in agricultural and food sectors. For example, bilateral import quotas on grains were suggested by the Chinese government during the negotiations on Chinese membership in the WTO. Bilateral export quotas played a significant role in the Multi-Fiber Agreement as part of the Uruguay Round (BACH and PEARSON 1996, p.4 and p.15). Moreover, quota restrictions for total imports into a certain region have been applied, e.g. by the EU on banana

imports from Latin American countries (EUROPEAN COMMISSION 1993). Finally, production quotas on milk and sugar in the EU should be mentioned.

In a linearized representation of a non-linear AGE model it is not always straightforward to implement explicit value or quantity restrictions. As long as the quota restriction is binding, the relevant quantity variable can be fixed exogenously, while making the corresponding policy variable endogenous. However, in two cases this approach fails do work: first, if the status of a quota shifts from binding to non-binding, as it often occurs with bilateral export or import quotas; and second, if an export or import "tax" contains two elements, the tax equivalent of a quota and also an "ordinary" import tariff or export subsidy.

BACH and PEARSON (1996) have developed a method to model any kind of inequality using the GEMPACK software package. The basic idea is to introduce additional value, price and quantity variables in those parts of the model where quantitative restrictions or other inequalities could be applicable. For example, concerning imports of a certain commodity into a certain region there are two relevant price levels in the standard model, the world market *cif* price (*PCIF*) and the domestic market price including any tariff or tax (*PMS*).<sup>25</sup> For modeling an import quota, an additional price (*PIS*) and, hence, value level is defined in between. Without import quotas, *PIS* would be equal to *PMS*. If the import quota is binding, however, *PMS* would be greater than *PIS*. Any "ordinary" import tariff on top of the quota can be modeled independently in the standard way, i.e. as a wedge between *PIS* and *PCIF*. In BACH and PEARSON (1996) it is explained in more detail, how this can be included in the GTAP model code, and how the associated quota rents can be calculated. In order to derive sufficiently accurate results in the presence of quotas, a two-step solution strategy with different algorithms has to be applied.

# Imperfect competition

One of the basic assumptions in many AGE models is the existence of perfect competition in all industries. This is clearly an oversimplification of observed economic reality, since output as well as input markets are frequently characterized by some degree of imperfectly competitive behavior. Main issues in this respect are product

<sup>&</sup>lt;sup>25</sup>Upper-case letters are used for the variables here as the price *levels* are considered.

differentiation and economies of scale. SWAMINATHAN and HERTEL (1996) show one possible way of how imperfect competition can be dealt with in an AGE model. However, modeling of imperfect competitive industries requires profound changes to the model structure.

Consumers in modern economies have very diverse preferences, i.e. their utility increases when there are many distinct varieties of the same product available on the market. This was termed the "love of variety" by LANCASTER (1979). The same can also be observed with respect to firms' demand for intermediate inputs. Producers respond to this diversity by producing differentiated brands of principally the same good. The supply of differentiated products implies fixed costs for research and development (R&D) as well as marketing. Even if production occurs at constant returns to scale, the fixed costs give rise to increasing returns to scale in sales and, hence, imperfect competition. Firms determine their price by adding a markup to their marginal costs in order to recoup the fixed cost from R&D and marketing (SWAMINATHAN and HERTEL 1996, p.2). Typically, industries which are characterized by high expenditures on advertising or R&D include food processing, beverages, textiles, automobiles, electronics, and other durable goods. In these sectors imperfect competition is more likely to occur. On the other hand, primary agriculture, natural resources, and mining are assumed to be closer to perfect competition (SWAMINATHAN and HERTEL 1996, p.2).<sup>26</sup>

In addition to the more traditional treatments of oligopoly and monopolistic competition<sup>27</sup>, recent developments in industrial organization theory have strongly increased the number of different oligopoly models. However, many of these theoretical models are unsuitable for implementation in economy-wide AGE models, as they require information on the strategic interaction between firms in imperfectly competitive industries which is usually not available. Hence, the Chamberlin model of monopolistic competition (CHAMBERLIN 1933) has been widely used in applied models. It abstracts from local firm rivalry and uses a representative consumer for modeling the preferences of all private households (SWAMINATHAN and HERTEL 1996, p.4). The Chamberlin model has been criticized for two reasons. First, firms can never really act

<sup>&</sup>lt;sup>26</sup>Of course, at a very disaggregated level probably any industry shows some degree of product differentiation. This is usually neglected in aggregated AGE models.

<sup>&</sup>lt;sup>27</sup>These include models by Cournot, Bertrand, and Chamberlin, which are discussed in KREPS (1990, Chapter 10).

as local monopolists, as they have to face the competition of their direct neighbors. This situation usually would be better described by a local oligopoly (KREPS 1990, p.345-346). Second, if any consumer only buys one variety of a differentiated product at a time, he or she can hardly represent a whole group of consumers. Nevertheless, it is probably impossible to describe imperfect competition in a unique way, and the Chamberlin model captures at least some of the important aspects in a consistent way.

Implementing monopolistic competition in the GTAP model affects the behavioral assumptions on consumers as well as producers. Demand for final goods and intermediate inputs does no longer distinguish between domestic and imported goods. The Armington assumption has been criticized for being an ad-hoc product differentiation. It implies that in the standard model bilateral imports of a certain commodity only enter a region as an *aggregate* import good. In contrast, in the monopolistic competition model domestic as well as imported products directly compete for the demand of various agents in a certain region. This tremendously increases the model size in terms of new equations, variables and parameters. Also, the structure of the database has to be altered.

With respect to the structure of production, the modeler first has to decide which industries are characterized by perfect competition and which reveal imperfectly competitive behavior. Then, a markup on average variable costs is introduced which is dependent on the elasticity of substitution between differentiated products. Moreover, the number of firms within an industry enters the model as a new *endogenous* variable. It is important to note that there is a one-to-one relationship between varieties and firms. The possibility of endogenous entry and exit of firms into or from an industry assures overall zero profits, i.e. the difference between revenues and total costs, in each sector. The details of the necessary modifications to model structure and data, together with the model code, are discussed in SWAMINATHAN and HERTEL (1996, p.7-24).

Simulation results from the modified GTAP model include, in addition to the standard industry-wide results, changes in the number of varieties in a certain industry (variety effect) as well as changes in output per firm (scale effect) (SWAMINATHAN and HERTEL 1996, p.30). Hence, with this model specification the pro-competitive effect of trade liberalization can be explored. The monopolistic competition model might also be

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useful for applications of GTAP to the transition countries, where market power and other market imperfections prevail in many formerly state-owned industries.

#### International capital mobility and dynamics

To conclude the section on possible extensions to standard AGE models, some dynamic aspects like international capital mobility, foreign ownership and growth will be briefly discussed. These issues also have implications for projection experiments. Although medium-run projections can be done with the comparative-static version of the GTAP model (GEHLHAR et al. 1994), a dynamic version would yield an explicit time path and more realistic end-of-period results. However, dynamic modeling within the GTAP framework is still in a rather preliminary state.

FRANCOIS et al. (1996) explore the relationship between trade, investment, and growth with an extended GTAP model. This is not accounted for in the standard version with exogenously fixed savings rates and fixed regional capital endowments. However, classical growth theory suggests that trade liberalization potentially affects medium-run capital accumulation through induced changes in regional savings and investment patterns. With an endogenous savings rate the medium-run impact of trade policy reforms can differ quite substantially from the pure static effects. Capital accumulation can reinforce, but in some cases also reverse, the static results and should be given more attention in policy modeling (FRANCOIS et al. 1996, p.1-2). Together with economies of scale effects, as discussed earlier, the total welfare gains from trade liberalization are probably much larger than those obtained from pure static analysis.

Perfect international capital mobility can only be covered in a truly dynamic model. MCDOUGALL and IANCHOVICHINA (1996) have developed a dynamic extension to the GTAP model in which regional capital stocks are endogenous and *time* is included as a new variable for determining the length of the modeling period. In addition, the reallocation of endowment capital across regions is made possible, which also has to deal with the question of explicit capital ownership, i.e. foreign or domestic. However, data on bilateral international capital flows are not available. Instead, a "global fund" is installed which handles all international capital transfers. In addition, investment is treated in a partial adjustment mode in order to avoid extreme volatility in the short-run (MCDOUGALL and IANCHOVICHINA 1996, p.3).

The question of foreign capital ownership is also closely related to the appearance of foreign direct investment and multinational enterprises (MNE). Clearly, these are of growing importance in a globalizing economy and will most likely affect the results from trade policy analysis. The equilibrium theory of international trade has long been separated from industrial organization approaches to the multinational enterprise (MARKUSEN 1998, p.1). Only recently there has been some progress in integrating MNE into AGE models. Basic conditions for MNE to evolve are firm-specific fixed costs as well as plant-specific fixed costs as well as trade and transportation costs and differences in factor intensities (MARKUSEN 1998, p.6). If parameters for these conditions can be found, equilibrium trade and foreign investment regimes can be derived in relatively simple AGE models. This might be a good starting point for future implementations of MNE in a global trade model like GTAP.

Traditionally, the limits to complex economic modeling were set by the available computer hardware and software technology. This is hardly a restriction any more. Moreover, there is a huge variety of theoretical models for the treatment of up-to-date economic issues, like imperfect competition or multinational firms. The restrictions to more advanced AGE modeling are rather given by the limited availability of appropriate data, e.g. sector-specific information on firms' behavior, bilateral investment flows, or elasticity parameters in general. However, this section has demonstrated that, even under current circumstances, there are various promising extensions available for making AGE analysis more realistic.

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### Appendix A-2.1 The Global Trade Analysis Project Model Code

This appendix shows the complete model code for the standard GTAP model.<sup>28</sup> The code is used for implementing the model in the GEMPACK software package. First, the relevant files and sets have to be defined, followed by the model variables. In Section A-2.1.2 the database coefficients and parameters are read into the model, and various derivatives of the base data are calculated. Section A-2.1.3 provides the equations which describe the theory of the model. Finally, in Section A-2.1.4 various summary indicators are listed.

#### A-2.1.1: Definition of Files, Sets, and Variables

GTAPDATA # The file containing all base data. # ; FILE FILE (TEXT) GTAPPARM # The file containing behavioral parameters. # ; GTAPSETS # File with set specification #; FILE SET REG # Regions in the model # MAXIMUM SIZE 10 READ ELEMENTS FROM FILE gtapsets HEADER "H1"; **SET** TRAD\_COMM # TRADED COMMODITIES # MAXIMUM SIZE 10 READ ELEMENTS FROM FILE gtapsets HEADER "H2"; SET NSAV\_COMM # NON-SAVINGS COMMODITIES # MAXIMUM SIZE 14 READ ELEMENTS FROM FILE gtapsets HEADER "H3"; SET DEMD COMM # DEMANDED COMMODITIES # MAXIMUM SIZE 13 READ ELEMENTS FROM FILE gtapsets HEADER "H4"; SET PROD COMM # PRODUCED COMMODITIES # MAXIMUM SIZE 11 READ ELEMENTS FROM FILE gtapsets HEADER "H5"; SET ENDW\_COMM # ENDOWMENT COMMODITIES # MAXIMUM SIZE 3 READ ELEMENTS FROM FILE gtapsets HEADER "H6"; SET ENDWS\_COMM # Sluggish ENDOWMENT COMMODITIES # MAXIMUM SIZE 3 READ ELEMENTS FROM FILE gtapsets HEADER "H7"; SET ENDWM\_COMM # Mobile ENDOWMENT COMMODITIES # MAXIMUM SIZE 3 READ ELEMENTS FROM FILE gtapsets HEADER "H8"; SET CGDS\_COMM # CAPITAL GOODS Commodities # MAXIMUM SIZE 1 READ ELEMENTS FROM FILE gtapsets HEADER "H9"; **SET** ENDWC\_COMM # Capital Endowment Commodity # (capital) ; SUBSET PROD\_COMM IS SUBSET OF NSAV\_COMM SUBSET DEMD\_COMM IS SUBSET OF NSAV\_COMM SUBSET TRAD\_COMM IS SUBSET OF DEMD\_COMM ; SUBSET TRAD\_COMM IS SUBSET OF PROD\_COMM ; SUBSET ENDW\_COMM IS SUBSET OF DEMD\_COMM ; SUBSET CGDS\_COMM IS SUBSET OF NSAV\_COMM SUBSET CGDS\_COMM IS SUBSET OF PROD\_COMM ; SUBSET ENDWS\_COMM IS SUBSET OF ENDW\_COMM; SUBSET ENDWM\_COMM IS SUBSET OF ENDW\_COMM;

<sup>&</sup>lt;sup>28</sup>This is the GTAP model file GTAP94.TAB. Throughout the Appendix, the model code is typed in Courier letters, while notes and comments are typed in Times Roman.
SUBSET ENDWC\_COMM IS SUBSET OF NSAV\_COMM;

# Quantity variables

VARIABLE #	(all,i,NSAV_COMM)(all,r,REG) industry output of commodity i in region r # ;	qo(i,r)
VARIABLE #	(all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG) supply of sluggish endowment i used in j, in r # ;	qoes(i,j,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) export sales of commodity i from r to region s # ;	qxs(i,r,s)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) sales of i from r to international transport # ;	qst(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) domestic sales of commodity i in r # ;	qds(i,r)
VARIABLE #	(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) demand for endowment i for use in j in region r # ;	qfe(i,j,r)
VARIABLE #	(all,j,PROD_COMM)(all,r,REG) value-added in industry j of region r  # ;	qva(j,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) demand for commodity i for use in j in region r # ;</pre>	qf(i,j,r)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) industry demands for aggregate imports # ;	qfm(i,j,s)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) industry demands for domestic goods # ;	qfd(i,j,s)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) private household demand for commodity i in region r # ;</pre>	qp(i,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) government household demand for commodity i in region r #</pre>	qg(i,r) ;
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) private hhld demand for imports of i in region s # ;	qpm(i,s)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) private hhld demand for domestic i in region s # ;	qpd(i,s)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,s,REG) government hhld demand for imports of i in region s # ;</pre>	qgm(i,s)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) government hhld demand for domestic i in region s # ;	qgd(i,s)
VARIABLE #	(all, r, REG) capital services = qo("capital",r) # ;	ksvces(r)
VARIABLE #	(all, r, REG) output of capital goods sector = qo("cgds",r) # ;	qcgds(r)
VARIABLE #	(all,r,REG) regional demand for NET savings # ;	qsave(r)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) aggregate imports of i in region s # ;	qim(i,s)
VARIABLE	(all,i,TRAD_COMM)(all,s,REG)	qiw(i,s)

#	aggregate imports of i in region s, cif weights # ;	
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) aggregate exports of i from region r, fob weights # ;	qxw(i,r)
VARIABLE #	(all,r,REG) volume of merchandise exports, by region # ;	qxwreg(r)
VARIABLE #	(all,r,REG) volume of merchandise imports, by region # ;	qiwreg(r)
VARIABLE #	(all,i,TRAD_COMM) volume of global merchandise exports by commodity # ;	qxwcom(i)
VARIABLE #	(all,i,TRAD_COMM) volume of global merchandise imports by commodity # ;	qiwcom(i)
VARIABLE #	volume of world trade # ;	qxwwld
VARIABLE #	(all,i,TRAD_COMM) quantity index for world supply of good i # ;	qow(i)
VARIABLE #	(all, r, REG) beginning-of-period capital stock, in r # ;	kb(r)
VARIABLE #	(all, r, REG) end-of-period capital stock, in r # ;	ke(r)
VARIABLE #	global supply of capital goods for NET investment # ;	globalcgds
VARIABLE #	quantity of global shipping services provided # ;	qt
VARIABLE #	(all,r,REG) regional population # ;	pop(r)
VARIABLE #	demand in the omitted marketglobal demand for savings #	walras_dem ;
VARIABLE #	supply in omitted marketglobal supply of cgds composite	walras_sup #;
VARIABLE #	(all,r,REG) GDP quantity index # ;	qgdp(r)

# Price variables

VARIABLE #	<pre>(all,i,NSAV_COMM)(all,r,REG) supply price of commodity i in region r # ;</pre>	ps(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) firms' price for commodity i for use in j, in r # ;	pf(i,j,r)
VARIABLE #	(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) firms' price for endowment commodity i in j of r # ;	pfe(i,j,r)
VARIABLE #	<pre>(all,j,PROD_COMM)(all,r,REG) firms' price of value-added in industry j of region r # ;</pre>	pva(j,r)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) price index for imports of i by j in region s #;	pfm(i,j,s)
VARIABLE	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)	pfd(i,j,s)

#	price index for domestic purchases of ${\tt i}$ by ${\tt j}$ in region ${\tt s}$ :	#;
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) private household price for commodity i in region r # ;</pre>	pp(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) price of imports of i by private households in s # ;	ppm(i,s)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) price of domestic i to private households in s # ;	ppd(i,s)
VARIABLE #	<pre>(all,r,REG) price index for govt hhld expenditures in region r # ;</pre>	pgov(r)
VARIABLE #	(all,r,REG) price index for private household expenditures in region :	<pre>ppriv(r) r # ;</pre>
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) government household price for commodity i in region r #</pre>	pg(i,r) ;
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,s,REG) price of imports of i by government households in s # ;</pre>	pgm(i,s)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,s,REG) price of domestic i to government households in s # ;</pre>	pgd(i,s)
VARIABLE #	<pre>(all,i,NSAV_COMM)(all,r,REG) market price of commodity i in region r # ;</pre>	pm(i,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) market price of composite import i in region r # ;</pre>	pim(i,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) world price of composite import i in region r # ;</pre>	piw(i,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG) aggregate exports price index of i from region r # ;</pre>	pxw(i,r)
VARIABLE #	<pre>(all,r,REG) price index of merchandise exports, by region # ;</pre>	pxwreg(r)
VARIABLE #	<pre>(all,r,REG) price index of merchandise imports, by region # ;</pre>	piwreg(r)
VARIABLE #	<pre>(all,i,TRAD_COMM) price index of global merchandise exports by commodity #</pre>	pxwcom(i)
VARIABLE #	<pre>(all,i,TRAD_COMM) price index of global merchandise imports by commodity #</pre>	piwcom(i) ;
VARIABLE #	price index of world trade # ;	pxwwld
VARIABLE #	<pre>(all,i,TRAD_COMM) World price index for total good i supplies #;</pre>	pw(i)
VARIABLE #	<pre>(all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG) market price of sluggish endowment used by j, in r # ;</pre>	pmes(i,j,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) domestic price for good i supplied from r to region s # ;</pre>	pms(i,r,s)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) FOB world price of commodity i supplied from r to s # ; ! i.e., prior to incorporation of transportation margin !</pre>	pfob(i,r,s)
VARIABLE	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)	pcif(i,r,s)

#	CIF world price of commodity i supplied from r to s #; ! i.e., subsequent to incorporation of transportation marg	gin !
VARIABLE #	price of global shipping services provided # ;	pt
VARIABLE #	(all, r, REG) rental rate on capital = ps("capital",r) # ;	rental(r)
VARIABLE #	(all, r, REG) Current net rate of return on capital stock, in r # ;	rorc(r)
VARIABLE #	(all, r, REG) Expected net rate of return on capital stock, in r # ;	rore(r)
VARIABLE #	Global net rate of return on capital stock # ;	rorg
VARIABLE #	price of capital goods supplied to savers # ;	psave
VARIABLE #	(all, r, REG) price of investment goods = ps("cgds",r) # ;	pcgds(r)
VARIABLE #	(all,r,REG) Index of prices received for tradables produced in r # ; ! Note: this includes sales of net investment in r !	psw(r)
VARIABLE #	<pre>(all,r,REG) Index of prices paid for tradables used in region r # ; ! Note: this includes purchases of net savings in region :</pre>	<b>pdw(r)</b>
VARIABLE #	<pre>(all,r,REG) terms of trade for region r: tot(r) = psw(r) - pdw(r) # ;</pre>	tot(r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) ratio of domestic to imported prices in r # ;	pr(i,r)
VARIABLE #	(all,r,REG) GDP price index # ;	pgdp(r)

# Technical change variables

VARIABLE #	<pre>(all,j,PROD_COMM)(all,r,REG) output augmenting technical change in sector j of r # ;</pre>	ao(j,r)
VARIABLE #	<pre>(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) primary factor i augmenting tech change in j of r # ;</pre>	afe(i,j,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) composite interm. input i augmenting tech change in j of p</pre>	<b>af(i,j,r)</b> c # ;
VARIABLE #	(all,i,PROD_COMM)(all,r,REG) Value added augmenting tech change in sector i of r # ;	ava(i,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) tech change parameter in shipping of i from region r to s</pre>	atr(i,r,s) # ;

# Policy variables

VARIABLE #	<pre>(all,i,NSAV_COMM)(all,r,REG) output (or income) tax in region r # ;</pre>	to(i,r)
VARIABLE #	(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) tax on primary factor i used by j in region r # ;	tf(i,j,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) tax on imported i purchased by private hhlds in r # ;	tpm(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) tax on domestic i purchased by private hhld in r # ;	tpd(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) tax on imported i purchased by gov't hhld in r # ;	tgm(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) tax on domestic i purchased by government hhld in r # ;	tgd(i,r)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) tax on imported i purchased by j in r # ;	tfm(i,j,r)
VARIABLE #	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) tax on domestic i purchased by j in r # ;	tfd(i,j,r)
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) combined tax in r on good i bound for region s # ;</pre>	txs(i,r,s)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) import tax in s on good i imported from region r # ;	tms(i,r,s)
VARIABLE #	(all,i,TRAD_COMM)(all,s,REG) variable import levy source generic # ;	tm(i,s)
VARIABLE #	(all,i,TRAD_COMM)(all,r,REG) variable export tax (subsidy) destination generic # ;	tx(i,r)

# Value, income and utility variables

VARIABLE #	<pre>(all,r,REG) value of merchandise exports, by region # ;</pre>	vxwreg(r)
VARIABLE #	(all,r,REG) value of merchandise imports, by region, at world prices #	viwreg(r) ;
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,s,REG) value of merchandise regional imports, by commodity, cif #</pre>	viwcif(i,s) ;
VARIABLE #	<pre>(all,i,TRAD_COMM)(all,s,REG) value of merchandise regional exports, by commodity, fob #</pre>	vxwfob(i,s) ;
<b>VARIABLE</b> #	(all,i,TRAD_COMM) value of global merchandise exports by commodity # ;	vxwcom(i)
VARIABLE #	(all,i,TRAD_COMM) value of global merchandise imports by commodity, at world	<b>viwcom(i)</b> l prices # ;
VARIABLE #	value of world trade # ;	vxwwld
VARIABLE #	<pre>(all,i,TRAD_COMM) value of world supply of good i # ;</pre>	valuew(i)

VARIABLE #	(all,r,REG) change in value of GDP # ;	vgdp(r)	
VARIABLE #	(all,r,REG) regional household income, in region r # ;	y(r)	
VARIABLE #	(all,r,REG) regional private household expenditure, in region r # ;	yp(r)	
VARIABLE #	(all,r,REG) per capita utility from private expend., in region r #;	up(r)	
VARIABLE #	(all,r,REG) per capita utility from gov't expend., in region r #;	ug(r)	
VARIABLE #	(all,r,REG) per capita utility from aggregate hhld expend., in region	<b>u(r)</b> r # ;	
VARIABLE #	(CHANGE)(all,r,REG) Equivalent Variation, \$ US million # ; ! Hicksian equivalent variation. Positive figure indicates welfare improvement !	EV(r)	
VARIABLE #	(CHANGE) Equivalent variation for the world # ;	WEV	
VARIABLE #	(CHANGE)(all,r,REG) Change in trade balance X - M, \$ US million # ; ! Positive figure indicates increase in exports exceeds in	DTBAL(r)	
VARIABLE #	(CHANGE)(all,i,TRAD_COMM)(all,r,REG) Change in trade balance by commodity and by region, \$ US to ! Positive figure indicates increase in exports exceeds in	DTBALi(i,r) million #; mports. !	
Slack variables			
VARIABLE #	<pre>(all,j,PROD_COMM)(all,r,REG) prof: slack variable in the zero profit equation # ! This is exogenous, unless the user wishes to specify output in a given region exogenously. !;</pre>	itslack(j,r)	
VARIABLE #	<pre>(all,r,REG) inco slack variable in the expression for regional income # ! This is exogenous, unless the user wishes to fix regional</pre>	<pre>meslack(r) al income!;</pre>	

VARIABLE (all,i,ENDW\_COMM)(all,r,REG) endwslack(i,r)
# slack variable in the endowment market clearing condition #
! This is exogenous, unless the user wishes to fix
the wage rate for one of the primary factors ! ;

VARIABLE (all, r, REG) cgdslack(r)
# slack variable for qcgds(r) #
! This is exogenous, unless the user wishes to specify
the level of new capital goods in a region ! ;

VARIABLE (all,r,REG) saveslack(r)
# slack variable in regional demand for savings #
! This is exogenous unless the user wishes to fix the
level of savings in a region. ! ;

VARIABLE (all,r,REG) govslack(r)
# slack variable to permit fixing of real govt purchases #
! This is exogenous unless the user wishes to fix the
level of government purchases. ! ;

VARIABLE	(all,i,TRAD_COMM)(all,r,REG)	<pre>tradslack(i,r)</pre>
#	slack variable in the tradables market clearing cond:	ition #
	! This is exogenous unless the user wishes to specify	Ι
	the price of tradables exogenously ! ;	

#### VARIABLE

walraslack

# slack variable in the omitted market #
 ! This is endogenous under normal, GE closure. If the GE links are
 broken, then this must be swapped with the numeraire, thereby
 forcing global savings to explicitly equal global investment. ! ;

## A-2.1.2 Database Coefficients and Parameters

## Base revenues and expenditures at agents' prices

```
COEFFICIENT (all, i, ENDW_COMM)(all, r, REG)
                                                                 EVOA(i,r)
         ! value of commodity i output in region r. ! ;
UPDATE (all, i, ENDW COMM)(all, r, REG)
      EVOA(i,r) = ps(i,r) * qo(i,r) ;
COEFFICIENT (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                                EVFA(i,j,r)
          ! producer expenditure on i by industry j,
            in region r, valued at agents' prices ! ;
UPDATE (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
      EVFA(i,j,r) = pfe(i,j,r) * qfe(i,j,r) ;
COEFFICIENT (all,r,REG)
                                                                 SAVE(r)
          ! expenditure on NET savings in region r
            valued at agents' prices ! ;
UPDATE (all,r,REG) SAVE(r) = psave * qsave(r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                               VDFA(i,j,r)
         ! purchases of domestic i for use in j in region r ! ;
UPDATE (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      VDFA(i,j,r) = pfd(i,j,r) * qfd(i,j,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VIFA(i,j,r)
         ! purchases of imported i for use in j in region r ! ;
UPDATE (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      VIFA(i,j,r) = pfm(i,j,r) * qfm(i,j,r) ;
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                VDPA(i,r)
         ! private household expenditure on domestic i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VDPA(i,r) = ppd(i,r) * qpd(i,r) ;
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                VIPA(i,r)
          ! private household expenditure on imported i ! ;
UPDATE (all, i, TRAD_COMM)(all, r, REG)
      VIPA(i,r) = ppm(i,r) * qpm(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                 VDGA(i,r)
        ! government household expenditure on domestic i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VDGA(i,r) = pgd(i,r) * qgd(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                 VIGA(i,r)
         ! government household expenditure on imported i ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VIGA(i,r) = pgm(i,r) * qgm(i,r) ;
COEFFICIENT (all, r, REG)
                                                                VKB(r)
         ! value of beginning-of-period capital stock, in region r ! ;
UPDATE (all, r, REG) VKB(r) = kb(r) * pcqds(r);
```

### Base revenues and expenditures at market prices

```
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
                                                               VXMD(i,r,s)
         ! exports of commodity i from region r to destination s valued at
           market prices (tradables only) ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
      VXMD(i,r,s) = pm(i,r) * qxs(i,r,s) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                VST(i,r)
          ! exports of commodity i from region r for international
           transportation valued at market prices (tradables only) ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG) VST(i,r) = pm(i,r) * qst(i,r) ;
COEFFICIENT (all, i, ENDW_COMM)(all, j, PROD_COMM)(all, r, REG)
                                                               VFM(i,j,r)
         ! producer expenditure on i by industry j,
           in region r, valued at market prices ! ;
UPDATE (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG)
      VFM(i,j,r) = pm(i,r) * qfe(i,j,r) ;
UPDATE (all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG)
       VFM(i,j,r) = pmes(i,j,r) * qfe(i,j,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                              VIFM(i,i,r)
         ! purchases of imports i for use in j in region r ! ;
UPDATE (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      VIFM(i,j,r) = pim(i,r) * qfm(i,j,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                              VDFM(i,j,r)
         ! purchases of domestic i for use in j in region r ! ;
UPDATE (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      VDFM(i,j,r) = pm(i,r) * qfd(i,j,r);
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)
                                                                VIPM(i,r)
         ! private household expenditure on i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VIPM(i,r) = pim(i,r) * qpm(i,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)
                                                                VDPM(i,r)
         ! private household expenditure on domestic i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VDPM(i,r) = pm(i,r) * qpd(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                VIGM(i,r)
         ! gov't household expenditure on i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VIGM(i,r) = pim(i,r) * qgm(i,r) ;
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                VDGM(i,r)
        ! government household expenditure on domestic i in r ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)
      VDGM(i,r) = pm(i,r) * qgd(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)(all, s, REG)
                                                                VIMS(i,r,s)
          ! imports of commodity i from region r to s, valued
           at domestic market prices ! ;
UPDATE (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
      VIMS(i,r,s) = pms(i,r,s) * qxs(i,r,s) ;
```

## Base revenues and expenditures at world prices

## Regional income, utility and population

```
COEFFICIENT (PARAMETER) (all,r,REG)
                                                                INC(r)
     ! initial equilibrium regional expenditure data INC is set equal to
      INCOME and does not change during a simulation ! ;
COEFFICIENT (all,r,REG)
                                                                URATIO(r)
    ! ratio of U(r), the per capita utility, to its presimulation value!;
FORMULA (Initial)(all,r,REG)
    URATIO(r) = 1;
UPDATE (all,r,REG)
    URATIO(r) = u(r);
COEFFICIENT (all,r,REG)
                                                                POPRATIO(r)
  ! ratio of POP(r), population in region r, to its presimulation value! ;
FORMULA (Initial)(all,r,REG)
    POPRATIO(r) = 1;
UPDATE (all,r,REG)
    POPRATIO(r) = pop(r);
```

## Technology and preference parameters

COEFFICIENT !	<pre>(all,i,TRAD_COMM)(all,r,REG) the substitution parameter in the CDE minimum expend function!;</pre>	<b>SUBPAR(i,r)</b> diture
COEFFICIENT !	(all,i,TRAD_COMM)(all,r,REG) expansion parameter in the CDE minimum expenditure i	<pre>INCPAR(i,r) function! ;</pre>
COEFFICIENT !	<pre>(all,i,TRAD_COMM) the elasticity of substitution between domestic and imported goods in the Armington aggregation structus for all agents in all regions. !;</pre>	<b>ESUBD(i)</b> re
COEFFICIENT !	<pre>(all,i,TRAD_COMM) the elasticity of substitution among imports from different destinations in the Armington aggregation structure of all agents in all regions. !;</pre>	ESUBM(i)
COEFFICIENT !	(all,j,PROD_COMM) elasticity of substitution between capital, labor, a possibly land, in the production of value-added in ;	<b>ESUBVA(j)</b> and j !;
COEFFICIENT !	(all,i,ENDWS_COMM) ETRAE is the elasticity of transformation for slugg factor endowments. It is non-positive, by definition	ETRAE(i) ish primary on.! ;

COEFFICIENT (all, r, REG) RORFLEX is the flexibility of expected net rate of return on capital stock, in region r, with respect to investment. If a region's capital stock increases by 1%, then it is expected that the net rate of return on capital will decline by RORFLEX %!;

#### COEFFICIENT

#### RORDELTA

! RORDELTA is a binary coefficient which determines
the mechanism of allocating investment funds across regions.
When RORDELTA = 1, investment funds are allocated
across regions to equate the change in the expected
rates of return (i.e., rore(r)). When RORDELTA = 0, investment
funds are allocated across regions to maintain the existing
composition of capital stocks !;

## "Read" statements for model parameters and base data

READ READ READ READ READ READ	SUBPARFROMFILEGTAPPARM;INCPARFROMFILEGTAPPARM;ESUBDFROMFILEGTAPPARM;ESUBVAFROMFILEGTAPPARM;ETRAEFROMFILEGTAPPARM;RORFLEXFROMFILEGTAPPARM;	
READ	RORDELTA FROM FILE GTAPPARM ;	
READ	(all,1,ENDW_COMM)(all,r,REG)	EVOA(i,r)
	(all, i, ENDW_COMM) (all, j, PROD_COMM) (all, r, REG)	EVFA(i,j,r)
	(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)	VIFA(i,j,r)
	(all, i, TRAD_COMM) (all, j, PROD_COMM) (all, r, REG)	VDFA(i,j,r)
	(all,i,TRAD_COMM)(all,r,REG)	VIPA(i,r)
	(all,i,TRAD_COMM)(all,r,REG)	VDPA(i,r)
	(all,i,TRAD_COMM)(all,r,REG)	VIGA(i,r)
	(all,i,TRAD_COMM)(all,r,REG)	VDGA(i,r)
	(all,r,REG)	SAVE(r)
	(all,r,REG)	VKB(r)
	(all,r,REG)	VDEP(r)
	<pre>FROM FILE GTAPDATA HEADER "VDEP" ; (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)</pre>	VXMD(i,r,s)
	FROM FILE GTAPDATA HEADER "VXMD" ; (all,i,TRAD_COMM)(all,r,REG)	VST(i,r)
	FROM FILE GTAPDATA HEADER "VST" ; (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)	VFM(i,j,r)
	FROM FILE GTAPDATA HEADER "VFM" ; (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)	VIFM(i,j,r)
	FROM FILE GTAPDATA HEADER "VIFM" ; (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)	VDFM(i,j,r)
	(all,i,TRAD_COMM)(all,r,REG)	VIPM(i,r)
	(all,i,TRAD_COMM)(all,r,REG)	VDPM(i,r)
	FROM FILE GTAPDATA HEADER "VDPM" ; (all,i,TRAD_COMM)(all,r,REG)	VIGM(i,r)
	<pre>FROM FILE GTAPDATA HEADER "VIGM" ; (all,i,TRAD_COMM)(all,r,REG)</pre>	VDGM(i,r)

	FROM FILE GTAPDATA HEADER "VDGM" ;
VIMS(i,r,s)	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
	FROM FILE GTAPDATA HEADER "VIMS" ;
VXWD(i,r,s)	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
	FROM FILE GTAPDATA HEADER "VXWD" ;
VIWS(i,r,s)	(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
	FROM FILE GTAPDATA HEADER "VIWS" ;

## Derivatives of the base data

After the base data have been read, a variety of derivatives of these value flows can be defined. These derivatives are not directly stored in the database in order to avoid redundancies. Various share coefficients are also defined which simplify later calculations in the model. The value of total GDP in each region is also calculated from the base data in this section.

## Values and shares

```
ZERODIVIDE (ZERO_BY_ZERO) DEFAULT 0 ;
COEFFICIENT (all, i, DEMD_COMM)(all, j, PROD_COMM)(all, r, REG)
                                                                 VFA(i,j,r)
          ! producer expenditure on i by industry j,
            in region r, valued at agents' prices ! ;
FORMULA (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
      VFA(i,j,r) = EVFA(i,j,r) ;
FORMULA (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)
      VFA(i,j,s) = VDFA(i,j,s) + VIFA(i,j,s) ;
COEFFICIENT (all, i, NSAV_COMM) (all, r, REG)
                                                                  VOA(i,r)
         ! value of commodity i output in region r. ! ;
FORMULA (all,i,ENDW_COMM)(all,r,REG)
      VOA(i,r) = EVOA(i,r);
FORMULA (all,i,PROD_COMM)(all,r,REG)
     VOA(i,r) = sum(j,DEMD_COMM, VFA(j,i,r));
                                                                  VDM(i,r)
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
          ! domestic sales of commodity i in region r
            valued at market prices (tradables only) ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
      VDM(i,r) = VDPM(i,r) + VDGM(i,r) + sum(j, PROD_COMM, VDFM(i,j,r));
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                  VIM(i,r)
          ! value of imports of commodity i in r
            at domestic market prices ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
       VIM(i,r) = sum(j,PROD_COMM, VIFM(i,j,r)) + VIPM(i,r) + VIGM(i,r) ;
COEFFICIENT (all, i, NSAV_COMM)(all, r, REG)
                                                                  VOM(i,r)
          ! value of commodity i output in region r. ! ;
FORMULA (all,i,ENDW_COMM)(all,r,REG)
     VOM(i,r) = sum(j,PROD_COMM, VFM(i,j,r)) ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     VOM(i,r) = VDM(i,r) + sum(s,REG, VXMD(i,r,s)) + VST(i,r);
FORMULA (all,h,CGDS_COMM)(all,r,REG)
     VOM(h,r) = VOA(h,r) ;
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                  VPA(i,r)
          ! private household expenditure on commodity i
```

```
in region r valued at agents' prices ! ;
FORMULA (all,i,TRAD_COMM)(all,s,REG)
     VPA(i,s) = VDPA(i,s) + VIPA(i,s) ;
                                                                 PRIVEXP(r)
COEFFICIENT (all,r,REG)
          ! private consumption expenditure in region r ! ;
FORMULA (all,r,REG) PRIVEXP(r) = sum(i,TRAD_COMM, VPA(i,r)) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                 VGA(i,r)
          ! government household expenditure on commodity
            i in region r valued at agents' prices ! ;
FORMULA (all,i,TRAD_COMM)(all,s,REG)
     VGA(i,s) = VDGA(i,s) + VIGA(i,s) ;
COEFFICIENT (all,r,REG)
                                                                 GOVEXP(r)
         ! government expenditure in region r ! ;
FORMULA (all,r,REG) GOVEXP(r) = sum(i,TRAD_COMM, VGA(i,r)) ;
COEFFICIENT (all,r,REG)
                                                                 INCOME(r)
          ! level of expenditure, which equals NET income in region r
            (i.e. net of capital depreciation) ! ;
FORMULA (all,r,REG)
     INCOME(r) = sum(i,TRAD_COMM, VPA(i,r) + VGA(i,r)) + SAVE(r) ;
FORMULA (INITIAL) (all,r,REG)
     INC(r) = INCOME(r) ;
      ! The above stores the initial value of INCOME as the parameter INC !
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
                                                                 VTWR(i,r,s)
          ! value of transportation services associated with
            the shipment of commodity i from r to s ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
     VTWR(i,r,s) = VIWS(i,r,s) - VXWD(i,r,s) ;
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
                                                                FOBSHR(i,r,s)
        ! The fob share in VIW. ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
     FOBSHR(i,r,s) = VXWD(i,r,s)/VIWS(i,r,s) ;
                                                                TRNSHR(i,r,s)
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)(all, s, REG)
         ! The transport share in VIW. ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
     TRNSHR(i,r,s) = VTWR(i,r,s)/VIWS(i,r,s) ;
COEFFICIENT
                                                                 VT
         ! The value of total international transportation services. !;
FORMULA VT = sum(i,TRAD_COMM, sum(r,REG, sum(s,REG, VTWR(i,r,s)))) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                                 SHRDFM(i,j,r)
      ! the share, at market prices, of domestic prod used by sector \texttt{j} !;
FORMULA (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      SHRDFM(i,j,r) = VDFM(i,j,r)/VDM(i,r);
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                 SHRDPM(i,r)
       ! share of domestic production used by private hhlds ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     SHRDPM(i,r) = VDPM(i,r)/VDM(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                  SHRDGM(i,r)
         ! share of imports from r in s used by gov't hhld ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     SHRDGM(i,r) = VDGM(i,r)/VDM(i,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
                                                              SHRIFM(i,j,r)
         ! share of imports in r used by sector j ! ;
FORMULA (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
      SHRIFM(i,j,r) = VIFM(i,j,r)/VIM(i,r) ;
```

```
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                  SHRIPM(i,r)
        ! the share of imports in r used by private hhlds ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     SHRIPM(i,r) = VIPM(i,r)/VIM(i,r) ;
COEFFICIENT (all, i, TRAD_COMM)(all, r, REG)
                                                                 SHRIGM(i,r)
          ! the share of imports from r used by gov't hhld ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     SHRIGM(i,r) = VIGM(i,r)/VIM(i,r) ;
COEFFICIENT (all, r, REG)
                                                                 REGINV(r)
          ! regional GROSS investment in region r,
          i.e., value of output of sector "cgds" ! ;
FORMULA (all, r, REG)
     REGINV(r) = sum(k,CGDS_COMM, VOA(k,r)) ;
COEFFICIENT (all, r, REG)
                                                                 NETINV(r)
         ! regional NET investment in region r ! ;
FORMULA (all, r, REG)
     NETINV(r) = sum(k,CGDS_COMM, VOA(k,r)) - VDEP(r) ;
COEFFICIENT
                                                                 GLOBINV
          ! global expenditures on net investment ! ;
          ! here, GLOBINV is computed as sum of NETINV(r) !
          ! alternatively, GLOBINV may be computed as sum of SAVE(r) !
FORMULA GLOBINV = sum(r,REG, NETINV(r));
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)
                                                                 VXW(i,r)
         ! The value of exports, at fob prices, by commodity and region! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
       VXW(i,r) = sum(s,REG, VXWD(i,r,s)) + VST(i,r);
COEFFICIENT (all,r,REG)
                                                                 VXWREGION(r)
         ! The value of exports, fob, by region ! ;
FORMULA (all,r,REG)
     VXWREGION(r) = sum(i,TRAD_COMM, VXW(i,r)) ;
                                                                 VXWCOMMOD(i)
COEFFICIENT (all, i, TRAD_COMM)
         ! The value of world exports, fob, by commodity ! ;
FORMULA (all, i, TRAD_COMM)
       VXWCOMMOD(i) = sum(r,REG, VXW(i,r)) ;
COEFFICIENT (all, i, TRAD_COMM)(all, s, REG)
                                                                 VIW(i,s)
 ! The value of commodity imports, at cif price, by commodity and region!;
FORMULA (all,i,TRAD_COMM)(all,s,REG)
       VIW(i,s) = sum(r,REG, VIWS(i,r,s)) ;
COEFFICIENT (all,r,REG)
                                                                 VIWREGION(r)
         ! The value of commodity imports, cif, by region ! ;
FORMULA (all,r,REG)
       VIWREGION(r) = sum(i,TRAD_COMM, VIW(i,r)) ;
COEFFICIENT (all, i, TRAD_COMM)
                                                                 VIWCOMMOD(i)
          ! The global value of commodity imports, cif, by commodity ! ;
FORMULA (all, i, TRAD_COMM)
       VIWCOMMOD(i) = sum(r,REG, VIW(i,r)) ;
COEFFICIENT
                                                                 VXWLD
         ! The value of commodity exports, fob, globally ! ;
FORMULA VXWLD = sum(r,REG, VXWREGION(r)) ;
COEFFICIENT (all,r,REG)
                                                                 VWLDSALES(r)
    ! The value of sales/purchases to/from the world market from/by r. ! ;
     ! NOTE: The difference between VWLDSALES(r) and
    ! VXWREGION(r) is that the former includes NETINV(r) !
FORMULA (all,r,REG)
     VWLDSALES(r) = sum(i,TRAD_COMM, sum(s,REG, VXWD(i,r,s))
```

+ VST(i,r)) + NETINV(r) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, r, REG) PW PM(i,r) ! Ratio of world to domestic prices ! ; FORMULA (all,i,TRAD\_COMM)(all,r,REG) PW\_PM(i,r) = sum(s,REG, VXWD(i,r,s)) / sum(s,REG, VXMD(i,r,s)) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, r, REG) VOW(i,r) ! Value of region's r output at fob prices! ; ! INCLUDING transportation services ! FORMULA (all,i,TRAD\_COMM)(All,r,REG) VOW(i,r) = VDM(i,r) \* PW\_PM(i,r) + sum(s,REG, VXWD(i,r,s)) + VST(i,r); **COEFFICIENT** (all, i, TRAD\_COMM) VWOW(i) ! Value of world supply at world prices for i. ! ; FORMULA (all, i, TRAD\_COMM) VWOW(i) = sum(r,REG, VOW(i,r)) ; **COEFFICIENT** (all,i,ENDW\_COMM)(all,j,PROD\_COMM)(all,r,REG) SVA(i,j,r) ! The share of i in total value-added in j in r.! ; FORMULA (all,i,ENDW\_COMM)(all,j,PROD\_COMM)(all,r,REG) SVA(i,j,r) = VFA(i,j,r)/sum(k,ENDW\_COMM, VFA(k,j,r)) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, s, REG) PMSHR(i,s) ! The share of aggregate imports in the domestic composite for private households, evaluated at agents' prices. ! ; FORMULA (all,i,TRAD\_COMM)(all,s,REG) PMSHR(i,s) = VIPA(i,s) / VPA(i,s) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, s, REG) GMSHR(i,s) ! The share of aggregate imports in the domestic composite for gov't households, evaluated at agents' prices. ! ; FORMULA (all,i,TRAD\_COMM)(all,s,REG) GMSHR(i,s) = VIGA(i,s) / VGA(i,s) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, j, PROD\_COMM) (all, s, REG) FMSHR(i,j,s) ! The share of aggregate imports in the domestic composite for firms, evaluated at agents' prices. ! ; FORMULA (all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,s,REG) FMSHR(i,j,s) = VIFA(i,j,s) / VFA(i,j,s) ; **COEFFICIENT** (all,i,TRAD\_COMM)(all,r,REG)(all,s,REG) MSHRS(i,r,s) ! The share of imports by source, r, in the aggregate import bill of region s evaluated at market prices. ! ; FORMULA (all, i, TRAD\_COMM)(all, r, REG)(all, s, REG) MSHRS(i,r,s) = VIMS(i,r,s) / sum(k,REG, VIMS(i,k,s)) ; **COEFFICIENT** (all, i, TRAD\_COMM) (all, r, REG) CONSHR(i,r) ! The share of private household consumption devoted to good i in region r. ! ; FORMULA (all,i,TRAD\_COMM)(all,r,REG) CONSHR(i,r) = VPA(i,r) / sum(m, TRAD\_COMM, VPA(m,r)) ; **COEFFICIENT** (all,i,ENDW\_COMM)(all,j,PROD\_COMM)(all,r,REG) REVSHR(i,j,r) FORMULA (all,i,ENDW\_COMM)(all,j,PROD\_COMM)(all,r,REG) ; REVSHR(i,j,r) = VFM(i,j,r)/sum(k,PROD\_COMM, VFM(i,k,r)); **COEFFICIENT** (all, r, REG) INVKERATIO(r) ! ratio of gross investment to end-of-period capital stock, in region r!; FORMULA (all, r, REG) INVKERATIO(r) = REGINV(r) / [VKB(r) + NETINV(r)] ; COEFFICIENT (all, r, REG) GRNETRATIO(r) ! ratio of GROSS/NET rates of return on capital, in region r ! ; ! NOTE: VOA("capital",r) is GROSS returns to capital ! FORMULA (all, r, REG) GRNETRATIO(r) = sum(h, ENDWC\_COMM, VOA(h,r)) /

[ sum(h, ENDWC\_COMM, VOA(h,r)) - VDEP(r) ]; COEFFICIENT (all,r,REG) GDP(r) ! Gross Domestic Product in region r. Trade is valued at fob and cif prices. !; FORMULA (all,s,REG) GDP(s) = sum(i,TRAD\_COMM, VPA(i,s)) + sum(i,TRAD\_COMM, VGA(i,s)) + sum(i,TRAD\_COMM, VOA(k,s)) + sum(i,TRAD\_COMM, sum(r,REG, VXWD(i,s,r)) + VST(i,s)) - sum(i,TRAD\_COMM, sum(r,REG, VIWS(i,r,s)));

## Computation of substitution, price and income elasticities

```
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                  ALPHA(i,r)
          ! one minus the substitution parameter in the CDE
           minimum expenditure function ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG) ! (HT#F1) !
     ALPHA(i,r) = (1 - SUBPAR(i,r));
COEFFICIENT (all, i, TRAD_COMM) (all, k, TRAD_COMM) (all, r, REG)
                                                                  APE(i,k,r)
          ! the Allen partial elasticity of substitution
            between composite goods i and k in region r !
FORMULA (all,i,TRAD_COMM)(all,k,TRAD_COMM)(all,r,REG) ! (HT#F2) !
      APE(i,k,r) = ALPHA(i,r) + ALPHA(k,r)
                 - sum(m,TRAD_COMM, CONSHR(m,r) * ALPHA(m,r)) ;
FORMULA (all,i,TRAD_COMM)(all,r,REG) ! (HT#F3) !
     APE(i,i,r) = 2.0 * ALPHA(i,r)
                 - sum(m,TRAD_COMM, CONSHR(m,r) * ALPHA(m,r))
                 - ALPHA(i,r) / CONSHR(i,r)
                                             ;
COEFFICIENT (all, i, TRAD_COMM) (all, r, REG)
                                                                  COMPDEM(i,r)
          ! the own-price compensated elasticity of
           household demand for composite commodity i ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
     COMPDEM(i,r) = APE(i,i,r) * CONSHR(i,r) ;
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)
                                                                  EY(i,r)
          ! the income elasticity of household demand for
            composite good i in region r !;
FORMULA (all,i,TRAD_COMM)(all,r,REG) ! (HT#F4) !
      EY(i,r) = \{1.0/[sum(m,TRAD_COMM, CONSHR(m,r) * INCPAR(m,r))]\}
              * (INCPAR(i,r) * (1.0 - ALPHA(i,r))
              + sum(m,TRAD_COMM, CONSHR(m,r) * INCPAR(m,r) * ALPHA(m,r)))
              + (ALPHA(i,r) - sum(m,TRAD_COMM, CONSHR(m,r) * ALPHA(m,r))) ;
COEFFICIENT (all, i, TRAD_COMM) (all, k, TRAD_COMM) (all, r, REG)
                                                                  EP(i,k,r)
          ! the uncompensated cross-price elasticity of hhld
            demand for good i with respect to the kth price in region r! ;
FORMULA (all,i,TRAD_COMM)(all,k,TRAD_COMM)(all,r,REG)! (HT#F5) !
     EP(i,k,r) = 0;
FORMULA (all,i,TRAD_COMM)(all,k,TRAD_COMM)(all,r,REG)
      EP(i,k,r) = (APE(i,k,r) - EY(i,r)) * CONSHR(k,r) ;
DISPLAY COMPDEM ; DISPLAY EY ;
ZERODIVIDE (ZERO_BY_ZERO) OFF ;
```

## Computation of technical dummy variables

```
D_EVFA(I,j,r) = 0;
FORMULA (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG: EVFA(i,j,r) > 0 )
       D_EVFA(I,j,r) = 1;
COEFFICIENT (all, i, TRAD_COMM)(all, j, PROD_COMM)(all, r, REG)
                                                                 D_VFA(i,j,r)
            ! 0, 1 variable for identifying zero expenditures in VFA. ! ;
FORMULA (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
       D_VFA(I,j,r) = 0;
FORMULA (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG: VFA(i,j,r) > 0 )
       D_VFA(I,j,r) = 1;
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
                                                                 D_VXWD(i,r,s)
           ! 0, 1 variable to identify zero expenditures in VXWD ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
       D_VXWD(i,r,s) = 0;
FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG: VXWD(i,r,s) > 0 )
       D_VXWD(i,r,s) = 1;
COEFFICIENT (all,i,TRAD_COMM)(all,r,REG)
                                                                 D_VST(i,r)
            ! 0, 1 variable to identify zero expenditures in VST ! ;
FORMULA (all,i,TRAD_COMM)(all,r,REG)
       D_VST(i,r) = 0;
FORMULA (all,i,TRAD_COMM)(all,r,REG: VST(i,r)>0)
       D_VST(i,r) = 1;
```

## Checking the base data

In this section the database is checked for consistency. According to neoclassical theory, in an initial general equilibrium there should be no extra profits, i.e. the total value of sales must be completely exhausted by the sum of payments to primary and intermediate factors of production. In addition, there should be no extra surplus, i.e. total income must be equal to total expenditure in each region.

```
PROFITS(j,r)
COEFFICIENT (all, j, PROD_COMM)(all, r, REG)
          ! profits in j of r. This should equal zero. ! ;
FORMULA (all,j,PROD_COMM)(all,r,REG)
      PROFITS(j,r) = VOA(j,r) - sum(i,DEMD_COMM, VFA(i,j,r));
COEFFICIENT (all,s,REG)
                                                                     SURPLUS(s)
          ! Economic surplus in region s. This should equal zero. NOTE: We
            first compute NET income from endowments and then income from
            various taxes. At the end we deduct private and government
            expenditures and net savings ! ;
FORMULA (all,r,REG)
SURPLUS(r) = sum(i,ENDW_COMM, VOA(i,r)) - VDEP(r)
           + sum(i,NSAV_COMM, VOM(i,r) - VOA(i,r))
           + sum(j,PROD_COMM, sum(i,ENDW_COMM, VFA(i,j,r) - VFM(i,j,r)))
           + sum(i,TRAD_COMM, VIPA(i,r) - VIPM(i,r))
           + sum(i,TRAD_COMM, VDPA(i,r) - VDPM(i,r))
           + sum(i,TRAD_COMM, VIGA(i,r) - VIGM(i,r))
           + sum(i,TRAD_COMM, VDGA(i,r) - VDGM(i,r))
           + sum(j,PROD_COMM, sum(i,TRAD_COMM, VIFA(i,j,r) - VIFM(i,j,r)))
+ sum(j,PROD_COMM, sum(i,TRAD_COMM, VDFA(i,j,r) - VDFM(i,j,r)))
           + sum(i,TRAD_COMM, sum(s,REG, VXWD(i,r,s) - VXMD(i,r,s)))
           + sum(i,TRAD_COMM, sum(s,REG, VIMS(i,s,r) - VIWS(i,s,r)))
           - sum(i,TRAD_COMM, VPA(i,r) + VGA(i,r))
            - SAVE(r) ;
```

```
DISPLAY PROFITS ; DISPLAY SURPLUS ;
```

## A-2.1.3 Model Equations

## Market clearing equations

#### Equation 2: MKTCLIMP

#### Equation 3: MKTCLDOM

#### Equation 4: MKTCLENDWM

! In each of the regions, this equation assures market clearing in the markets for endowment goods which are perfectly mobile among uses. (HT#4) ! (all,i,ENDWM\_COMM)(all,r,REG) VOM(i,r) \* qo(i,r) = sum(j,PROD\_COMM, VFM(i,j,r) \* qfe(i,j,r)) + VOM(i,r) \* endwslack(i,r) ;

#### Equation 5: MKTCLENDWS

```
! In each of the regions, this equation assures market clearing in the markets
for endowment goods which are imperfectly mobile among uses.(HT#5)!
(all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG)
goes(i,j,r) = qfe(i,j,r);
```

#### Equation 6

#### Equation 7

```
!-----!
! Equation 7 generates a price index for transportation services based on !
! zero profits. Refer to the global transportation sector equations below.!
!-----!
```

#### Equation 8: PRIVATEXP

#### Equation 9: REGIONALINCOME

! This equation computes regional income as the sum of primary factor payments and tax receipts. (HT#9) The first term computes the change in endowment income, net of depreciation. The subsequent terms compute the change in tax receipts for various transactions' taxes. Note that in each of these terms

```
the quantity change is common. This defines the common transaction which is
 being taxed. It is the prices which potentially diverge .!
(all,r,REG)
INCOME(r) * y(r)
 = sum(i, ENDW_COMM, VOA(i,r) * [ps(i,r) + qo(i,r)])
                     - VDEP(r) * [pcgds(r) + kb(r)]
+ sum(i,NSAV_COMM, {VOM(i,r) * [pm(i,r) + qo(i,r)]}
                    - {VOA(i,r) * [ps(i,r) + qo(i,r)]})
+ sum(i,ENDWM_COMM,sum(j,PROD_COMM,{VFA(i,j,r)
                    * [pfe(i,j,r) + qfe(i,j,r)] }
                    - {VFM(i,j,r)* [pm(i,r) + qfe(i,j,r)]}))
+ sum(i,ENDWS_COMM,sum(j,PROD_COMM,{VFA(i,j,r)
                    * [pfe(i,j,r) + qfe(i,j,r)]}
                    - {VFM(i,j,r) * [pmes(i,j,r) + qfe(i,j,r)]}))
+ sum(j,PROD_COMM, sum(i,TRAD_COMM,{VIFA(i,j,r)
                    * [pfm(i,j,r) + qfm(i,j,r)]}
                    - {VIFM(i,j,r) * [pim(i,r) + qfm(i,j,r)]}))
+ sum(j,PROD_COMM, sum(i,TRAD_COMM,{VDFA(i,j,r)
                     * [pfd(i,j,r) + qfd(i,j,r)]}
                    - {VDFM(i,j,r) * [pm(i,r) + qfd(i,j,r)]}))
+ sum(i,TRAD_COMM, {VIPA(i,r) * [ppm(i,r) + qpm(i,r)]}
                     - {VIPM(i,r) * [pim(i,r) + qpm(i,r)]})
+ sum(i,TRAD_COMM, {VDPA(i,r) * [ppd(i,r) + qpd(i,r)]}
                      \{VDPM(i,r) * [pm(i,r) + qpd(i,r)]\})
+ sum(i,TRAD_COMM, {VIGA(i,r) * [pgm(i,r) + qgm(i,r)]}
                     - \{ VIGM(i,r) * [pim(i,r) + qgm(i,r)] \} \}
+ sum(i,TRAD_COMM, {VDGA(i,r) * [pgd(i,r) + qgd(i,r)]}
- {VDGM(i,r) * [pm(i,r) + qgd(i,r)]})
+ sum(i,TRAD_COMM, sum(s,REG,{VXWD(i,r,s) * [pfob(i,r,s) + qxs(i,r,s)]}
                    - {VXMD(i,r,s) * [pm(i,r) + qxs(i,r,s)]}))
+ sum(i,TRAD_COMM, sum(s,REG,{VIMS(i,s,r) * [pms(i,s,r) + qxs(i,s,r)]}
                    - \{ VIWS(i,s,r) * [pcif(i,s,r) + qxs(i,s,r)] \} ) \}
+ INCOME(r) * incomeslack(r);
```

#### Equation 10: KEND

! Ending capital stock equals beginning stock plus net investment. (HT#10)! (all, r, REG)

ke(r) = INVKERATIO(r) \* qcgds(r) + [1.0 - INVKERATIO(r)] \* kb(r) ;

#### Equation 11

!-----!
! Equation 11 computes changes in global investment. Refer to Equation 11'!
! in the investment equations section below.
!------!

#### Equation 12: WALRAS\_S

! This is an extra equation which simply computes change in supply in the omitted market. (HT#12)! walras\_sup = globalcgds ;

#### Equation 13: WALRAS\_D

```
! This is an extra equation which simply computes change in demand in the
omitted market. (HT#13)!
GLOBINV * walras_dem = sum(r,REG, SAVE(r) * qsave(r));
```

#### GLOBINV WAILAS\_ACII = SUII(1, KEG, SAVE(1) 4SAVC

#### Equation 14: WALRAS

! This equation checks Walras' Law. The value of the endogenous slack variable should be zero. (HT#14)! walras\_sup = walras\_dem + walraslack ;

## Price linkage equations

#### Equation 15: SUPPLYPRICES

! This equation links pre- and post-tax supply prices for all industries. This captures the effect of output taxes. TO(i,r) < 1 in the case of a

```
tax. (HT#15)!
(all,i,NSAV_COMM)(all,r,REG)
ps(i,r) = to(i,r) + pm(i,r);
```

#### Equation 16: MPFACTPRICE

! This equation links domestic and firm demand prices. It holds for mobile endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#16)! (all,i,ENDWM\_COMM)(all,j,PROD\_COMM)(all,r,REG) pfe(i,j,r) = tf(i,j,r) + pm(i,r);

#### Equation 17: SPFACTPRICE

! This equation links domestic and firm demand prices. It holds for sluggish endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#17)! (all,i,ENDWS\_COMM)(all,j,PROD\_COMM)(all,r,REG) pfe(i,j,r) = tf(i,j,r) + pmes(i,j,r);

#### Equation 18: PHHDPRICE

! This equation links domestic market and private household prices.It holds only for domestic goods and it captures the effect of commodity taxation of private households. (HT#18) ! (all,i,TRAD\_COMM)(all,r,REG) ppd(i,r) = tpd(i,r) + pm(i,r) ;

#### Equation 19: GHHDPRICE

! This equation links domestic market and government household prices. It holds only for domestic goods and it captures the effect of commodity taxation of government households. (HT#19) ! (all,i,TRAD\_COMM)(all,r,REG) pgd(i,r) = tgd(i,r) + pm(i,r) ;

#### Equation 20: DMNDDPRICE

! This equation links domestic market and firm prices. It holds only for domestic goods and it captures the effect of commodity taxation of firms. (HT#20)! (all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,r,REG) pfd(i,j,r) = tfd(i,j,r) + pm(i,r) ;

#### Equation 21: PHHIPRICES

! This equation links domestic market and private household prices. It holds only for imports and it captures the effect of commodity taxation of private households. (HT#21)! (all,i,TRAD\_COMM)(all,r,REG) ppm(i,r) = tpm(i,r) + pim(i,r) ;

#### Equation 22: GHHIPRICES

! This equation links domestic market and government household prices. It holds only for imports and it captures the effect of commodity taxation of government households. (HT#22)! (all,i,TRAD\_COMM)(all,r,REG) pgm(i,r) = tgm(i,r) + pim(i,r) ;

#### Equation 23: DMNDIPRICES

! This equation links domestic market and firm prices. It holds only for imported goods and it captures the effect of commodity taxation of firms. (HT#23)! (all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,r,REG) pfm(i,j,r) = tfm(i,j,r) + pim(i,r) ;

#### Equation 24: MKTPRICES

```
! This equation links domestic and world prices. It includes a
source-generic import levy. (HT#24)!
(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s) ;
```

#### Equation 25: PRICETGT

```
! This equation defines the target price ratio to be attained via the
  variable levy. (HT#25)!
(all,i,TRAD_COMM)(all,s,REG)
pr(i,s) = pm(i,s) - pim(i,s);
```

#### Equation 26

```
!-----!
! For Equation 26'refer to the equations on the global transportation sector!
! given below.
!------!
```

#### Equation 27: EXPRICES

! This equation links agents' and world prices. In addition to tx we have txs which embodies both production taxes (all s) and export taxes (r not equal to s) (HT#27)! (all,i,TRAD\_COMM)(all,r,REG)(all,s,REG) pfob(i,r,s) = pm(i,r) - tx(i,r) - txs(i,r,s);

## Behavioral equations of producers

### Equation 28: DPRICEIMP

! Price for aggregate imports. (HT#28)!
(all,i,TRAD\_COMM)(all,s,REG)
pim(i,s) = sum(k,REG, MSHRS(i,k,s) \* pms(i,k,s));

#### Equation 29: IMPORTDEMAND

#### Equation 30: ICOMPRICE

! Industry price for composite commodities. (HT#30) !
(all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,r,REG)
pf(i,j,r) = FMSHR(i,j,r)\*pfm(i,j,r) + [1 - FMSHR(i,j,r)]\*pfd(i,j,r) ;

#### Equation 31: INDIMP

! Industry j demands for composite import i. (HT#31)! (all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,s,REG) qfm(i,j,s) = qf(i,j,s)- ESUBD(i) \* [pfm(i,j,s) - pf(i,j,s)];

#### Equation 32: INDDOM

! Industry j demands for domestic good i. (HT#32)!
(all,i,TRAD\_COMM)(all,j,PROD\_COMM)(all,s,REG)
qfd(i,j,s) = qf(i,j,s) - ESUBD(i) \* [pfd(i,j,s) - pf(i,j,s)];

### Equation 33: VAPRICE

! (Effective) price of primary factor composite in each sector/region. (HT#33)! (all,j,PROD\_COMM)(all,r,REG) pva(j,r) = sum(k,ENDW\_COMM, SVA(k,j,r) \* [pfe(k,j,r) - afe(k,j,r)]);

#### Equation 34: ENDWDEMAND

#### Equation 35: VADEMAND

```
! Sector demands for primary factor composite. (HT#35)!
(all,j,PROD_COMM)(all,r,REG)
qva(j,r) + ava(j,r) = qo(j,r) - ao(j,r);
```

```
Equation 36: INTDEMAND
! Industry demands for intermediate inputs, including cgds. (HT#36) !
(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
qf(i,j,r) = D_VFA(i,j,r) * [ - af(i,j,r) + qo(j,r) - ao(j,r) ];
Equation 6': ZEROPROFITS
! Industry zero pure profits condition. This condition permits us to determine
  the endogenous output level for each of the non-endowment sectors. The level
  of activity in the endowment sectors is exogenously determined. (HT#6)!
(all,j,PROD_COMM)(all,r,REG)
VOA(j,r) * [ps(j,r) + ao(j,r)] =
    sum(i,ENDW_COMM, VFA(i,j,r) * [pfe(i,j,r) - afe(i,j,r)])
    + sum(i,TRAD_COMM, VFA(i,j,r);
```

## Behavioral equations of households

```
Equation 37: UTILITY
! computation of per capita regional utility (HT#37). Note that private
 utility has already been defined on a percapita basis. !
(all,r,REG)
INCOME(r) * u(r) = PRIVEXP(r) * up(r)
                 + GOVEXP(r) * [ ug(r) - pop(r) ]
                            * [ qsave(r) - pop(r)] ;
                 + SAVE(r)
Equation 38: SAVINGS
! regional demand for savings -- generated from aggregate Cobb-Douglas
 utility function where the pop(r) terms again cancel (HT#38)!
(all,r,REG)
qsave(r) = y(r) - psave + saveslack(r) ;
Equation 39: GOVERTU
! Computation of utility from regional government consumption. In
  some closures this index of gov't activity may be fixed, in which case
 govslack is endogenized. In this case the mix of regional expenditures
  changes and the aggregate utility index no longer applies. (HT#39)!
(all,r,REG)
ug(r) = y(r) - pgov(r) + govslack(r) ;
Equation 40: GPRICEINDEX
! definition of price index for aggregate gov't purchases (HT#40)!
(all,r,REG)
     pgov(r) = sum(i,TRAD_COMM, [VGA(i,r)/GOVEXP(r)] * pg(i,r)) ;
Equation 41: GOVDMNDS
! Government household demands for composite commodities. Note that the pop(r)
  argument in per capita income and that in per capita consumption cancel due
  to homotheticity. (HT#41)!
(all,i,TRAD_COMM)(all,r,REG)
qg(i,r) = ug(r) - [pg(i,r) - pgov(r)];
Equation 42: GCOMPRICE
! Government household price for composite commodities (HT#42)!
(all,i,TRAD_COMM)(all,s,REG)
pg(i,s) = GMSHR(i,s) * pgm(i,s) + [1 - GMSHR(i,s)] * pgd(i,s) ;
Equation 43: GHHLDAGRIMP
! Government household demand for aggregate imports. (HT#43)!
(all,i,TRAD_COMM)(all,s,REG)
qgm(i,s) = qg(i,s) + ESUBD(i) * [pg(i,s) - pgm(i,s)];
Equation 44: GHHLDDOM
! Government household demand for domestic goods. (HT#44)!
(all,i,TRAD_COMM)(all,s,REG)
qgd(i,s) = qg(i,s) + ESUBD(i) * (pg(i,s) - pgd(i,s)) ;
```

```
Equation 45: PRIVATEU
! This equation determines private consumption utility for a representative
household in region r, based on the per capita private expenditure function.
  (HT#45)!
(all,r,REG)
yp(r) = sum(i,TRAD_COMM, (CONSHR(i,r) * pp(i,r)))
  + sum(i,TRAD_COMM, (CONSHR(i,r) * INCPAR(i,r))) * up(r)
  + pop(r) ;
Equation 46: PRIVDMNDS
```

```
Equation 47: PCOMPRICE
```

```
! Private household price for composite commodities (HT#47)!
(all,i,TRAD_COMM)(all,s,REG)
pp(i,s) = PMSHR(i,s) * ppm(i,s) + [1 - PMSHR(i,s)] * ppd(i,s) ;
```

```
Equation 48: PHHLDDOM
```

```
! Private household demand for domestic goods. (HT#48)!
(all,i,TRAD_COMM)(all,s,REG)
qpd(i,s) = qp(i,s) + ESUBD(i) * [pp(i,s) - ppd(i,s)];
```

```
Equation 49: PHHLDAGRIMP
```

```
! Private household demand for aggregate imports. (HT#49)!
(all,i,TRAD_COMM)(all,s,REG)
qpm(i,s) = qp(i,s) + ESUBD(i) * [pp(i,s) - ppm(i,s)];
```

## Equations for sluggish endowments (imperfect factor mobility)

```
Equation 50: ENDW_PRICE
! This equation generates the composite price for sluggish endowments.(HT#50)!
(all,i,ENDWS_COMM)(all,r,REG)
pm(i,r) = sum(k,PROD_COMM, REVSHR(i,k,r) * pmes(i,k,r));
Equation 51: ENDW_SUPPLY
```

```
! This equation distributes the sluggish endowments across sectors. (HT#51)!
(all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG)
qoes(i,j,r) = qo(i,r) - endwslack(i,r)
+ ETRAE(i) * [pm(i,r) - pmes(i,j,r)];
```

#### Investment equations (macroeconomic closure)

```
Equation 52: KAPSVCES
! This equation defines a variable for capital services, for convenience.
  (There is really only one capital services item.) (HT#52)!
(all,r,REG)
ksvces(r) = sum(h,ENDWC_COMM, [VOA(h,r) / sum(k,ENDWC_COMM, VOA(k,r))]*
qo(h,r));
Equation 53: KAPRENTAL
```

```
! This equation defines a variable for capital rental rate. (HT#53)!
(all,r,REG)
rental(r) = sum(h,ENDWC_COMM, [VOA(h,r) / sum(k,ENDWC_COMM, VOA(k,r))] *
ps(h,r));
```

```
Equation 54: CAPGOODS
! This equation defines a variable for gross investment, for convenience.
  There is really only one capital goods item. )
                                                  (HT#54)!
(all,r.REG)
qcgds(r) = sum(h,CGDS_COMM, [VOA(h,r) / REGINV(r)] * qo(h,r)) ;
Equation 55: PRCGOODS
! This equation defines the price of cgds for convenience. (HT#55)!
(all,r,REG)
pcqds(r) = sum(h,CGDS_COMM, [VOA(h,r) / REGINV(r)] * ps(h,r)) ;
Equation 56: KBEGINNING
! This equation associates any change in capital services during the
 period with a change in capital stock. Full capacity utilization is
 assumed. (HT#56)!
(all,r,REG)
kb(r) = ksvces(r) ;
Equation 57: RORCURRENT
! This generates the current rate of return on capital in region r.(HT#57)!
(all, r, REG)
rorc(r) = GRNETRATIO(r) * [rental(r) - pcgds(r)] ;
Equation 58: ROREXPECTED
! \ \mbox{Expected rate of return depends on the current return and }
 investment.(HT#58)!
(all, r, REG)
rore(r) = rorc(r) - RORFLEX(r) * [ke(r) - kb(r)] ;
Equation 59: RORGLOBAL
! This equation computes alternatively the global supply of capital goods
 or the global rental rate on investment. (HT#59) !
(all.r.REG)
RORDELTA*rore(r)
+ [1 - RORDELTA] * {[REGINV(r)/NETINV(r)] * qcgds(r)
- [VDEP(r)/NETINV(r)] * kb(r)}
= RORDELTA * rorg + [1 - RORDELTA] * globalcgds + cgdslack(r) ;
Equation 11': GLOBALINV
! This equation computes: either the change in global investment (when
 RORDELTA=1), or the change in the expected global rate of return on capital
  (when RORDELTA=0) (HT#11') !
RORDELTA * globalcgds + [1 - RORDELTA] * rorg =
RORDELTA * [ sum(r,REG, {REGINV(r)/GLOBINV} * qcgds(r)- {VDEP(r)/GLOBINV} *
kb(r)]
+ [1 - RORDELTA] * [ sum(r,REG, {NETINV(r)/GLOBINV} * rore(r)) ];
Equation 60: PRICGDS
! This equation generates a price index for the aggregate
  global cgds composite. (HT#60) !
psave = sum(r,REG, [ NETINV(r) / GLOBINV] * pcgds(r)) ;
```

## Equations for the global transportation sector

#### Equation 7': PTRANS

! This equation generates a price index for transportation services based on zero profits. (NOTE Sales to international transportation are not subject to export tax. This is why we base the costs to the transport sector on market prices of the goods sold to international transportation.) (HT#7)! VT \* pt = sum(i,TRAD\_COMM, sum(r,REG, VST(i,r) \* pm(i,r)));

### Equation 61: TRANSVCES

! This equation generates the demand for regional supply of global transportation services. It reflects a unitary elasticity of substitution between transportation services inputs from different regions. (HT#61)!

(all,i,TRAD\_COMM)(all,r,REG)
qst(i,r) = D\_VST(i,r) \* [ qt + [pt - pm(i,r)] ];

```
! This equation links fob and cif prices for good i shipped from region r
to s . (HT#26')!
(all,i,TRAD_COMM)(all,r,REG)(all,s,REG)
pcif(i,r,s) = FOBSHR(i,r,s) * pfob(i,r,s) + TRNSHR(i,r,s) * [pt - atr(i,r,s)];
```

Equation 63: -

## A-2.1.4 Summary indicators

Equation 65: REGDEMPRICE

#### Equation 66: TOTeq

! Terms of trade equation computed as difference in psw and pdw. (HT#66) !
(all,r,REG)
tot(r) = psw(r) - pdw(r) ;

Equation 67: EVREG

```
! computes regional EV (HT#67)!
(all,r,REG)
EV(r) = [INC(r)/100] * [URATIO(r) * POPRATIO(r)] * [u(r) + pop(r)] ;
```

#### Equation 68: EVWLD

! computes EV for the world (HT#68)! WEV - sum(r,REG, EV(r)) = 0 ;

#### Equation 69: PHHLDINDEX

```
! computes change in price index for private household expenditures (HT#69)!
(all,r,REG)
PRIVEXP(r) * ppriv(r) = sum(i,TRAD_COMM, VPA(i,r)* pp(i,r));
```

#### Equation 70: VGDP\_r

```
Equation 71: PGDP_r
! gdp price index (HT#71)!
(all,r,REG)
GDP(r) * pgdp(r) = sum(i,TRAD_COMM, VGA(i,r) * pg(i,r) )
                 + sum(i,TRAD_COMM, VPA(i,r) * pp(i,r) )
                 + REGINV(r) * pcgds(r)
   + sum(i,TRAD_COMM, sum(s,REG, VXWD(i,r,s) * pfob(i,r,s) ))
                 + sum(i,TRAD_COMM, VST(i,r) * pm(i,r) )
   - sum(i,TRAD_COMM, sum(s,REG, VIWS(i,s,r)* pcif(i,s,r))) ;
Equation 72: QGDP_r
! gdp quantity index (HT#72)!
(all,r,REG)
qgdp(r) = vgdp(r) - pgdp(r) ;
Equation 73: VREGEX_ir
! the change in FOB value of exports of commodity i from r (HT#73)!
(all,i,TRAD_COMM)(all,r,REG)
VXW(i,r) * vxwfob(i,r) = sum(s,REG, VXWD(i,r,s) * [qxs(i,r,s) + pfob(i,r,s)])
                       + VST(i,r) * [gst(i,r) + pm(i,r)] ;
Equation 74: VREGIM_is
! the change in CIF value of imports of commodity i into s (HT#74)!
(all,i,TRAD_COMM)(all,s,REG)
VIW(i,s) * viwcif(i,s) = sum(r,REG, VIWS(i,r,s) * [pcif(i,r,s) + qxs(i,r,s)]);
Equation 75: VREGEX r
! computes % change in value of merchandise exports, by region (HT#75)!
(all,r,REG)
VXWREGION(r) * vxwreg(r) = sum(i,TRAD_COMM, VXW(i,r) * vxwfob(i,r)) ;
Equation 76: VREGIM_s
! computes % change in value of imports, cif basis, by region (HT#76)!
(all,s,REG)
VIWREGION(s) * viwreg(s) = sum(i,TRAD_COMM, VIW(i,s) * viwcif(i,s)) ;
Equation 77: VWLDEX_i
! computes % change in fob value of global exports, by commodity (HT#77)!
(all,i,TRAD_COMM)
VXWCOMMOD(i) * vxwcom(i) = sum(r,REG, VXW(i,r) * vxwfob(i,r)) ;
Equation 78: VWLDIM_i
! computes % change in value of global imports, by commodity (HT#78)!
(all,i,TRAD_COMM)
VIWCOMMOD(i) * viwcom(i) = sum(s,REG, VIW(i,s) * viwcif(i,s)) ;
Equation 79: VWLDEX
! computes % change in value of global exports (HT#79)!
VXWLD * vxwwld = sum(r,REG, VXWREGION(r) * vxwreg(r)) ;
Equation 80: VWLDOUT
! change in value of world output of commodity i at fob prices (HT#80)!
(all, i, TRAD_COMM)
VWOW(i) * valuew(i) = sum(r,REG, VOW(i,r) * [pxw(i,r) + qo(i,r)]) ;
Equation 81: PREGEX_ir
! the change in FOB price index of exports of commodity i from r (HT#81)!
(all,i,TRAD_COMM)(all,r,REG)
VXW(i,r) * pxw(i,r) = sum(s,REG, VXWD(i,r,s) * pfob(i,r,s))
                    + VST(i,r) * pm(i,r) ;
Equation 82: PREGIM_is
! the change in cif price index of imports of commodity i into s (HT#82)!
(all,i,TRAD_COMM)(all,s,REG)
VIW(i,s) * piw(i,s) = sum(r,REG, VIWS(i,r,s) * pcif(i,r,s)) ;
```

Equation 83: PREGEX\_r

! computes % change in price index of exports, by region (HT#83)! (all,r,REG) VXWREGION(r) \* pxwreg(r) = sum(i,TRAD\_COMM, VXW(i,r) \* pxw(i,r)); Equation 84: PREGIM s ! computes % change in price index of imports, by region (HT#84)! (all,s,REG) VIWREGION(s) \* piwreg(s) = sum(i,TRAD\_COMM, VIW(i,s) \* piw(i,s)) ; Equation 85: PWLDEX\_i ! computes % change in price index of exports, by commodity (HT#85)! (all,i,TRAD\_COMM) VXWCOMMOD(i) \* pxwcom(i) = sum(r,REG, VXW(i,r) \* pxw(i,r)) ; Equation 86: PWLDIM\_i ! computes % change in price index of imports, by commodity (HT#86)! (all,i,TRAD\_COMM) VIWCOMMOD(i) \* piwcom(i) = sum(s,REG, VIW(i,s) \* piw(i,s)) ; Equation 87: PWLDEX ! computes % change in price index of global exports (HT#87)! VXWLD \* pxwwld = sum(r,REG, VXWREGION(r) \* pxwreg(r)) ; Equation 88: PWLDOUT ! change in index of world prices, fob, for total production of i (HT#88)! (all,i,TRAD\_COMM) VWOW(i) \* pw(i) = sum(r,REG, VOW(i,r) \* pxw(i,r)) ; Equation 89: QREGEX\_ir ! The change in volume of exports of commodity i from r. This is generated by deflating a value aggregate. (HT#89)! (all,i,TRAD\_COMM)(all,r,REG) qxw(i,r) = vxwfob(i,r) - pxw(i,r) ; Equation 90: QREGIM\_is ! The change in volume of imports of commodity i into s. This is generated by deflating a value aggregate. (HT#90)! (all,i,TRAD\_COMM)(all,s,REG) qiw(i,s) = viwcif(i,s) - piw(i,s);Equation 91: QREGEX\_r ! computes % change in quantity index of exports, by region (HT#91)! (all,r,REG) qxwreg(r) = vxwreg(r) - pxwreg(r) ; Equation 92: QREGIM\_s ! computes % change in quantity index of imports, by region (HT#92)! (all,s,REG) qiwreg(s) = viwreg(s) - piwreg(s) ; Equation 93: QWLDEX\_i ! computes % change in quantity index of exports, by commodity (HT#93)! (all,i,TRAD\_COMM) qxwcom(i) = vxwcom(i) - pxwcom(i) ; Equation 94: QWLDIM\_i ! computes % change in quantity index of imports, by commodity (HT#94)! (all,i,TRAD\_COMM) qiwcom(i) = viwcom(i) - piwcom(i) ; Equation 95: QWLDEX ! computes % change in quantity index of global exports (HT#95)! qxwwld = vxwwld - pxwwld ; Equation 96: QWLDOUT ! change in index of world production of i (HT#96)! (all,i,TRAD\_COMM)

qow(i) = valuew(i) - pw(i) ;

#### Equation 97: TRADEBAL\_i

! computes change in trade balance by commodity and by region (HT#97)!
(all,i,TRAD\_COMM)(all,r,REG)
DTBALi(i,r) = [VXW(i,r)/100] \* vxwfob(i,r) - [VIW(i,r)/100] \* viwcif(i,r) ;

## Equation 98: TRADEBALANCE

! computes change in trade balance (X - M), by region (HT#98)!
(all,r,REG)
DTBAL(r) = [VXWREGION(r)/100] \* vxwreg(r) - [VIWREGION(r)/100] \* viwreg(r);
!------!
! END OF FILE !

# 3 New Directions in the Common Agricultural Policy: Effects of Land and Labor Subsidies in a General Equilibrium Model

## 3.1 Introduction

The reform of the Common Agricultural Policy (CAP) in 1992 has introduced major changes to the system of agricultural support in the European Union (EU). For the first time since the establishment of the CAP, domestic prices for some agricultural products were brought down significantly closer to world market levels, and at the same time direct compensation payments were introduced. These are first steps in a direction which has been proposed by agricultural economists for years, and some positive effects can already be observed. Intervention stocks for grains and beef have decreased and domestic grains have become more competitive in the use for livestock feed. However, there are still many inefficiencies in the current policy system as well as newly created distortions. Hence, there is an ongoing discussion in academia and politics about further reforms of the CAP.

Most observers would agree that the CAP has to be simplified and further decoupled from production in order to cut down administrative expenses, increase transparency, and remove market and trade distortions. This will be important not only with respect to the upcoming negotiations in the World Trade Organization (WTO), but also in the process of preparing for an Eastern enlargement of the EU. One way of modifying the CAP could be the introduction of uniform payments on agricultural labor and/or land as a substitute for current support measures. If designed properly, factor subsidies would be far less distorting than product-related compensation payments, they would most likely reduce administrative expenses and probably meet WTO obligations. However, some production effects can still be expected, since factor subsidies draw resources out of other sectors into agriculture and thus slow down structural changes in the farm sector.

In a recent study by KIRSCHKE et al. (1997), the effects of direct factor payments were analyzed with a focus on farm level results in a German context. This paper covers the same policy options for the EU as a whole in a more aggregated, economy-wide perspective. An applied general equilibrium (AGE) model with an appropriate disaggregation in agricultural sub-sectors is used for the analysis. The model not only allows for the implementation of specific agricultural policy measures, but also keeps track of resource flows into and out of agriculture under various policy options. In addition to that, a multi-regional AGE model generates results with respect to international trade and welfare.

The next section briefly evaluates the CAP after the reform in 1992. Section 3.3 provides an overview of proposals for further development of EU agricultural policies with a focus on factor subsidies. Theoretical effects of factor subsidies are analyzed in Section 3.4. After explaining the structure of the AGE model and the policy implementation, selected simulation results are discussed in 3.6. The final section draws some conclusions and gives further implications for modeling the CAP.

## 3.2 The Situation after the 1992 Common Agricultural Policy Reform

The 1992 CAP reform has achieved more than most observers would have expected from looking at earlier policy adjustments. Prices for grains, oilseeds and protein seeds have been brought down closer to world market levels. Compensation payments have been at least partially decoupled from market production. Politicians claim that the reform has solved some of the problems related to over-production, above all the high levels of government purchases (BMELF 1997, p.80-81). In 1992/93, the EU had about 33 million tons of grain in intervention stocks, whereas in 1995/96 less than 3 million tons remained. The use of domestic grains for livestock feed in the EU increased significantly from 94 million tons in 1993/94 to 106 million tons in 1996/97 (UHLMANN 1997, p.26-27).

On the other hand, there is considerable "unfinished business" in the 1992 reform (MAHÉ and ROE 1996, p.1). Products like milk, sugar, wine, fruits and vegetables were excluded from the 1992 reform. Output restrictions for milk and sugar are still in place and the design of current product-related compensation payments has led to new distortions between various agricultural products. Compensation payments under the new CAP are linked to agricultural land and the number of livestock per farm. They are not really decoupled from production since farmers have to produce in order to receive the compensation payments. Factors of production are now driven into those products where protection and hence profitability is still high compared to more liberalized

markets. This works against the pressure for structural change that could be expected from lower prices. Less efficient farms are kept in production, thus preventing new farmers from expanding their operations (WISSENSCHAFTLICHER BEIRAT 1997, p.2-3).

Price ratios between products within the EU are not in line with ratios prevailing on world markets, as many restrictions with respect to international trade are still in operation (KIRSCHKE et al. 1997, p.3). Signals from world markets still do not directly affect farmers' decisions within the EU. One striking example was the case of high grain prices in 1995, when the EU introduced export *taxes* in order to keep grain prices at those administratively low levels that were chosen as a base for income compensation in 1992. This is clearly against the idea of internationally interacting markets, where production shortages in one region can be compensated for by other regions which prevents extreme volatility of world market prices.

Politicians still consider quantitative restrictions as an appropriate means of regulating output as well as factor markets. Production quotas on the farm level for milk and sugar were not touched by the 1992 reform. Following the Blair-House agreement, the current compensation system for oilseeds is in fact a quantitative restriction on a regional level, as e.g. in Germany the national overall quantities eligible for compensation payments have been transferred to the Federal States. Even further distribution down to the farm level is being discussed (WISSENSCHAFTLICHER BEIRAT 1997, p.6). On the market for agricultural land, the set-aside programs are more restrictive than before 1992. Originally, set-aside was a voluntary measure for output reduction and protection of environmentally sensitive areas, but after the reform farmers are practically forced to set aside part of their land by design of the compensation system. In many cases, highly fertile land is not utilized whereas in other regions small farmers on marginal land are exempt from set-aside requirements. This is another example of misallocation of resources. With respect to environmental goals the induced production in marginal areas might even be counterproductive.

It is very likely that the 1992 CAP reform has increased the administrative burden related to agricultural support programs. First, there is a whole variety of compensation payments linked to specific crop and livestock products which complicates their administration. Second, farmers' compliance with set-aside requirements is hard to monitor in practice and there are many incentives to circumvent the obligations. The

complexity of the system has initiated the use of monitoring technology via satellite in order to check set-aside requirements on every single farm. These activities are clearly a consequence of new policy incentives and are not related to real agricultural production. It seems that the implementation of the reformed CAP on the farm level has increased paper work for farmers tremendously. More time is spent applying for various government payments and finding an optimal mix of support measures for each specific farm. Such a complicated system is prone to rent-seeking activities, and a simplification would lead to a more efficient resource use.

However, apart from distortions of agricultural markets there is more external pressure for further reform of the CAP. First of all, as a consequence of shifting agricultural protection more towards direct compensation payments, EU budget expenditures on agriculture have increased from about 35 billion ECU in 1992 to about 45 billion ECU in 1996 (EUROPEAN COMMISSION 1997a, p.T/102).<sup>1</sup> The next EU financial round will start in 1999 and the agricultural guideline, i.e. a maximum increase in the agricultural budget at 74 percent of the GDP growth rate, might come under debate. Demand for reduced protection in the farm sector combined with simplified administration and reduced expenditures can be expected. Also in 1999, the next round of negotiations in the WTO is about to start. The current system of compensation payments in EU agriculture will certainly undergo investigation again, and a further liberalization of sectors not touched by the 1992 reform is a likely scenario. Without this the EU might not be able to meet current WTO bindings with regard to subsidized exports (TANGERMANN and MARSH 1996, p.7-8; KIRSCHKE et al. 1997, p.3).

Another, if not the most important, external motivation for a "reform of the reform" is the expected EU integration of several Central European countries (CEC). Even though the first new members will probably not join the union before 2003 (AGRA EUROPE 4/1997, p.E20), some problems are already obvious. First, a significant increase in budget expenditures can be expected, if the CAP is introduced in the CEC without modification. Estimates of enlargement costs are between 3.5 and 40.5 billion ECU (BUCKWELL et al. 1994; TANGERMANN et al. 1994; TARDITI et al. 1994; MAHÉ et al. 1995; DIW 1996). Second, if the CEC implemented current EU levels of agricultural support, some of them would clearly violate the upper bounds for protection that were

<sup>&</sup>lt;sup>1</sup> This is, of course, partly due to the integration of Austria, Finland and Sweden.

agreed upon in the Uruguay Round under the General Agreement on Tariffs and Trade (GATT). From a WTO perspective an integration of the CEC would be very difficult if the level of agricultural support were not reduced by the EU-15 first (TWESTEN 1998).

## 3.3 The Discussion about a "Reform of the Reform"

The issues mentioned so far are a starting point for the discussion about a further reform of the CAP. Recently, the EU Commission presented an Agenda 2000 providing perspectives for the general development of the European Union at the beginning of the next millennium (EUROPEAN COMMISSION 1997b). The proposals include a decrease of intervention prices for grains (- 20 percent), beef (- 30 percent) and milk (- 10 percent), the introduction of a uniform compensation payment for grains, oilseeds and voluntary set-aside as well as direct payments per animal for beef cattle and dairy cows. Furthermore, set-aside requirements are set to zero and the milk quota system is being extended until the year 2006, while there are no changes to the sugar quota. With regard to the sum of all direct payments per individual farm an upper limit is discussed in the Agenda 2000, and the EU Commission also proposes more flexibility for regional authorities such that direct payments can be linked to environmental objectives. All in all, the proposals by the Commission do not imply major changes to the current agricultural policy system. Although intervention prices for grains, beef and milk will be significantly lower, quantitative restrictions are not abolished. For dairy cows even a new direct payment is introduced which will probably lead to additional administrative costs.

KIRSCHKE et al. (1997) provide an overview of other proposals for a reform of the 1992 CAP reform that are currently under debate. There is a wide spectrum as regards the extent of the policy changes. While e.g. the government of the German federal state of Bavaria rejects significant modifications to the current CAP and favors "appropriate" border protection (BAYRISCHE STAATSREGIERUNG 1995), the British government suggests bold steps towards a liberalized agricultural policy (AGRA EUROPE 3/1997, p.E1-2). The economic council at the German ministry of agriculture recently proposed further decoupling of compensation payments, reduction of border protection, abolishment of set-aside requirements and introduction of a uniform payment on agricultural land (WISSENSCHAFTLICHER BEIRAT 1997).

With respect to financing the CAP in some new concepts more financial responsibility on a national or even regional level is discussed (MAFF 1995; BAYRISCHE STAATSREGIERUNG 1995). Uniform implementation of all CAP instruments throughout the EU is also under debate, since it is not clear whether, after an Eastern enlargement, the new members will receive all the benefits currently available from the EU budget (EUROPEAN COMMISSION 1996).

Taking into consideration the future requirements for the CAP and the current discussion described earlier, six specific options for a new agricultural policy will be analyzed in this paper (Table 3.1).

Table 3.1:Scenarios for a further development of the Common Agricultural<br/>Policy

	No subsidies	Land subsidy	Labor subsidy
Partial liberalization	plib_00	plib_lnd	plib_lab
Complete liberalization	lib_00	lib_lnd	lib_lab

Source: Adapted from KIRSCHKE et al. (1997).

Since the Agenda 2000 has been criticized for not going far enough in terms of liberalization of agricultural markets (e.g. KIRSCHKE et al. 1998; BALMANN et al. 1998), here a *partial liberalization* as well as a *complete liberalization* of the CAP will be considered in the scenarios. These basic options will then be combined with either no compensation, a uniform payment on agricultural land, or a uniform payment on agricultural labor. In the course of the 1992 CAP reform domestic prices for grains, oilseeds and protein crops have been brought down close to world market levels. In addition, the scenario *partial liberalization* includes the reduction of border protection for so-called "sensitive" commodities like beef, milk products and sugar by 10 percent. All set-aside requirements, compensation payments, and animal subsidies are dropped whereas the production quotas for milk and sugar remain in place. These changes will most likely cause a decrease in farm income. Land and labor subsidies are introduced for compensation. In the scenario *complete liberalization* all current CAP instruments (including quantity restrictions) are abolished and the same compensation payments as in the *partial liberalization* scenario are provided.

If the factor subsidies were independent of agricultural production, policy distortions that were created by the product-related subsidies in the 1992 reform could be reduced.

Whether or not factor subsidies would be "green box" compatible and, therefore, admissible in future WTO rounds primarily depends on the precise implementation. If the payments were fixed with respect to a historic base period and farmers' eligibility were limited to a certain number of years, they would be truly decoupled from actual production and would fall into the "green box". The duration of the payments could be chosen appropriately in order to enable farmers to adjust.

A considerable advantage of uniform factor payments compared to the current system would be simpler administration. Although this is not the scope of this paper it must be considered an important side-effect in the scenarios discussed below. Transfer efficiency of EU agricultural policies is very likely to be increased (WISSENSCHAFT-LICHER BEIRAT 1997, p.9). Another issue could become more important in the case of further regionalization of the CAP. Uniform payments could be easily modified or supplemented on the regional level according to local needs and preferences, especially in combination with environmental objectives. Again, these issues are not considered here.

Having mentioned some arguments in favor of factor subsidies, potentially negative aspects should not be neglected. Although the discussed factor payments may be less distorting in general, in the case of a land subsidy crop production will certainly gain more than livestock production and vice versa in the case of a labor subsidy. Moreover, resource flows from other sectors of the economy into agriculture are likely to occur. Especially in the case of a relatively mobile factor like labor allocation effects could be significant.

## 3.4 Theoretical Effects of Factor Subsidies

Before turning to empirical simulations, the theoretical effects of a factor subsidy will be discussed using a model developed by GARDNER (1990). In Appendix A-3.1, the effects are derived algebraically using an example with one output x and two inputs a and b. The implications of a subsidy for input a on product and factor markets are graphically demonstrated in Figure 3.1.

There is an output market and two input markets, each with a supply curve S, a demand curve D, and prices  $P_x$ ,  $P_a$  and  $P_b$ . A subsidy on input a leads to an increase in the use of

this factor. All other factors, in this case represented by b, are reduced. Output x is also increased due to lower factor prices. The changes on the markets for x and a go in the same direction as long as the elasticities have "normal" signs. The effects on market b can be reversed in the case that the elasticity of substitution between factors is smaller in absolute terms than the demand elasticity for the output (GARDNER 1990, p.109).

Figure 3.1: Price and quantity effects of an input subsidy for factor *a* on output and factor markets



Source: Adapted from GARDNER (1990, p.110).

Prices for output and both inputs are falling. However, on the market for input *a* one has to distinguish between the effective market price  $P_a^m$  and the factor price  $P_a$  perceived by the producer. Due to the subsidy the producer pays a price which is  $t_a$  units below the market price. As can be seen in the central diagram, rising demand for factor *a* causes the market price for *a* to rise whereas the perceived producer price is falling. This is important in a general equilibrium framework where the market price for factors of production is not fixed. Factors move between sectors if their value of marginal product is changing and part of the subsidy payment may be transferred through the market to the factor owners. The size of the effect depends on the elasticities in the model.

What are the effects of land or labor subsidies on the distribution of factor income? A land subsidy paid to the farmer who is actually working the land would be a very transparent measure of support. However, bargaining between land-owners and tenants would probably drive up land rents, and the policy objective of increased farm income would not be achieved in areas with a high share of tenant farms like in Eastern Germany. In general, regional land use is likely to change under uniform land subsidies.

Since the payment is independent of any specific kind of production, low-input farming including forestry would become more attractive on marginal land.

A labor subsidy would have very different effects. Since agriculture in the EU has only a small share in the economy-wide labor market, probably wage levels would not be very much affected by a subsidy in agriculture. However, important decisions would have to be made with regard to the duration, transferability and precise calculation of the labor subsidy. The basis for the payment could be the calculated labor requirement for a specific farm in order to avoid moral hazard in determining the labor force. If, for example, the right for support was personally assigned to current farmers and fixed to a reference point in time, it could become a tradable permit which would then be fully decoupled from any production activity. As a consequence, the value of agricultural assets including land would probably drop severely which might cause legal disputes related to property rights and policy credibility in general (WISSENSCHAFTLICHER BEIRAT 1997, p.28-29).

# 3.5 Implementation of Policy Scenarios in the Applied General Equilibrium Model

A multi-region AGE model seems to be an appropriate tool for the analysis of the policy options discussed earlier. It does not only focus on the agriculture and food sector, but allows for linkages to other parts of the economy. Resource flows between sectors induced by policy changes can be modeled more realistically than in a partial equilibrium setting. The model also covers international trade flows between regions which makes world market prices endogenous instead of keeping them fixed for a certain region. When unilateral policy changes are analyzed the implications for other regions are taken into account. By looking for a new price vector after a policy change the model assures equilibrium trade flows between regions.<sup>2</sup>

# Structure of the model

The AGE model used in this paper was developed by the Global Trade Analysis Project (GTAP) at Purdue University.<sup>3</sup> It is a global trade model that can be tailored according

<sup>&</sup>lt;sup>2</sup> For an overview of AGE applications to agricultural and food sectors see BROCKMEIER (1995).

<sup>&</sup>lt;sup>3</sup> A detailed description of the model is given in HERTEL and TSIGAS (1997) or at the internet site http://www.agecon.purdue.edu/gtap.
to specific needs by changing the aggregation of regions and sectors. In this case, the model aggregation covers 10 regions, each with 10 sectors in the economy. There is only one output per sector. The model regions are Australia/New Zealand, Canada, USA, Japan, EU-12, Austria/Finland/Sweden, EU-associated countries in Central Europe (CEC-7)<sup>4</sup>, the Former Soviet Union, Asia, and the Rest of the World.<sup>5</sup>

The following sectors are distinguished in the model:<sup>6</sup>

- Agriculture: wheat (*wht*), other grains (*gro*), non-grain crops (*ngc*), livestock (*olp*)
- Food industry: meat products (met), milk products (mil), other food products (ofp)
- Other sectors: primary products (*opp*), manufactures (*mnfcs*), services (*svces*).

The model structure on the production side, a so-called nested structure, is shown in Figure 3.2.



Figure 3.2: Production structure in the GTAP model

Source: Adapted from HERTEL and TSIGAS (1997, p.56).

Land, labor and capital as the primary factors of production are combined to a primary aggregate input using a constant-elasticity-of-substitution (CES) function. The same applies to domestic and imported intermediate inputs which are combined to an intermediate aggregate. The two aggregates then contribute to final output via a Leontief function. Capital and labor in the standard model are perfectly mobile *between* 

<sup>&</sup>lt;sup>4</sup> These are Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia.

<sup>&</sup>lt;sup>5</sup> The Rest-of-the-World region consists mainly of Latin America and Africa.

<sup>&</sup>lt;sup>6</sup> Acronyms for the sectors are in brackets.

sectors, but the total endowment with these factors *within* a region is fixed. Land is only used in primary agriculture and in the primary products (*opp*) sector. Mobility of land between these sectors is limited by an elasticity of transformation.

Main assumptions of the standard model are perfect competition on all markets as well as profit and utility maximizing behavior of producers and consumers, respectively. In modeling international trade flows the so-called Armington assumption is applied (ARMINGTON 1969). It is assumed that there is product differentiation by regions. This implies that for a certain product trade flows between two regions can always go in either direction at the same time and there is no net trade flow. The Armington assumption fits nicely with regularly observed discrepancies between world market prices for the same commodity at different locations. The change in world market prices in the GTAP model is calculated as a weighted average price index using bilateral trade flows as weights. The Armington assumption has also been criticized by many authors as it is not very flexible and does not endogenize aspects of imperfect competition and industrial organization into international trade. However, it still seems to be a reasonable compromise as detailed information on the competitive situation for various sectors is currently not available on a global basis (HERTEL and TSIGAS 1997, p.21-22). The macroeconomic closure of the model is accomplished by a "global bank" which assures an equilibrium of savings and investments between the model regions. In the standard closure used here, the regional shares in global investments are fixed. This closure rule is basically neoclassical, but it allows for some adjustment in the mix of investment on a regional level (HERTEL and TSIGAS 1997, p.28-30).

In the model, policy instruments such as taxes and subsidies can be implemented at various levels. Government intervention in the GTAP model principally works in the same way as discussed in the previous section. For the policy scenarios under consideration here, three instruments are used in particular: the degree of border protection, determined by the ratio between domestic price and world market price; product-related subsidies and direct payments, modeled as the ratio between domestic market price and effective producer price<sup>7</sup>; and finally, subsidies related to factors of production, calculated as the ratio between the market price and the perceived factor price by the producer.

<sup>&</sup>lt;sup>7</sup> This is also called the agents' price in the GTAP terminology.

The GTAP model in its standard version is comparative-static. All equations are in percentage change form.<sup>8</sup> In a simulation experiment one or more variables in the model are shocked exogenously by a certain percentage. After determining a new equilibrium, the changes in all endogenous variables are also expressed in percentage changes. The model is solved using the GEMPACK software package (HARRISON and PEARSON 1996).

## Database

The GTAP project has developed a comprehensive database using information from numerous international sources (MCDOUGALL 1997). The base year for the data is 1992. However, for further development of the CAP the reference scenario should be the situation in 1996 when the changes of the 1992 reform were supposed to be fully implemented. In order to update the database for the simulations in this paper, the changes of 1992 were implemented in the EU-12, i.e. price decreases for grains, oilseeds, protein seeds and meat products in connection with a set-aside program and direct compensation payments. Austria, Finland and Sweden were also integrated by creating the EU-15. The situation after these updates in 1996 was taken as a reference for modeling the new policy options as defined in Section 3.3.

# **Policy scenarios**

The technical implementation of the new policy measures in the GTAP model is shown in Table 3.2. The corresponding command files for the GEMPACK software are provided in Appendix A-3.2.

In the scenarios dealing with a *partial liberalization* of the CAP, all product-related direct payments are abolished. This includes compensation payments, set-aside payments and animal subsidies. The level of border protection in the GTAP database for non-grain crops (*ngc*), meat products (*met*) and milk products (*mil*) is reduced by 10 percent.<sup>9</sup> Actually, government intervention occurs primarily on the markets for sugar,

<sup>&</sup>lt;sup>8</sup> See HERTEL and TSIGAS (1997) for a detailed discussion of the model structure.

<sup>&</sup>lt;sup>9</sup> The level of border protection is determined by the ratio of the domestic price to the world market price. If, for example, in the initial situation the domestic price is 50 percent above the world market level, the ratio is 1.5. A reduction of border protection by 10 percent is equivalent to reducing the ratio to 1.35. If the world market price were exogenous this would exactly cause a 10 percent drop in the domestic price.

beef and milk. However, since the sector disaggregation in GTAP does not explicitly cover sugar and beef, the policy change is implemented in those sectors that include these products.

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
<b>Direct subsidies</b> <sup>a</sup>						
wht	Ab	olishment				
gro		of all		Al	oolishment	
ngc	prod	luct-related			of all	
olp	S	ubsidies		pro	duct-related	
met				t	axes and	
mil				:	subsidies	
ofp						
<b>Border protection</b> <sup>b</sup>						
wht						
gro				Al	oolishment	
ngc	- 10 %	- 10 %	- 10 %		of	
olp					border	
met	- 10 %	- 10 %	- 10 %	ŗ	protection	
mil	- 10 %	- 10 %	- 10 %			
ofp						
Land subsidy $^{\circ}$						
wht, gro, ngc, olp		75 %			75 %	
Labor subsidy <sup>c</sup>						
wht, gro, ngc, olp			14 %			14 %

Table 3.2:Model implementation of the scenarios

<sup>a</sup> Compensation payments, set-aside payments and animal payments

<sup>b</sup> Measured as the ratio domestic price/world market price; a reduction of border protection by 10 percent is equivalent to a reduction of the ratio by 10 percent.

<sup>c</sup> Direct factor payments, in percent of the relevant factor price

Source: KIRSCHKE et al. (1997); own calculations.

The level of new factor subsidies related to land and labor has been calculated as follows. The estimated budget expenditures on compensation payments, set-aside payments and animal subsidies in the EU in 1996 were about 18.7 billion ECU. This amount has been reduced by 10 percent and then divided by the value of agricultural land as well as the value of agricultural labor in the GTAP database for the EU-15.<sup>10</sup> This yields the level of factor subsidies in relative terms, i.e. the necessary policy

<sup>&</sup>lt;sup>10</sup>The reduction in expenditures by 10 percent was chosen arbitrarily, since it was assumed that some degree of budget reduction will be likely in any further CAP reform.

shocks to be implemented in the model. In scenario *plib\_00*, no factor subsidization occurs. In scenario *plib\_lnd* a land subsidy is applied at 75 percent of the factor price. The labor subsidy in scenario *plib\_lab* is determined at 14 percent.

In the scenarios covering a complete liberalization of the CAP, all border protection measures in agriculture and food products that remain after the reform in 1992 are abolished. Furthermore, all domestic output taxes and subsidies still in place in the food industry are taken away. In scenario *lib\_00* no compensation is provided for these policy changes. In the remaining scenarios *lib\_lnd* and *lib\_lab* the subsidization of land and labor is modeled in the same way as already described for the partial liberalization cases.

With respect to land as a production factor one also has to take into account the changes in set-aside regulations. Since set-aside requirements are set to zero in the policy scenarios covered here, the amount of land available for production is increased by about 5 percent. This is equivalent to the real share of the set-aside area in total agricultural land between 1992 and 1996 in the EU.

# 3.6 Selected Model Results

# Output

In Table 3.3, the percentage changes in output are shown for various sectors in the EU. The introduction of a pure land subsidy has hardly any production effects compared to the no-subsidy scenario. This issue will be discussed below in more detail. In order to avoid redundancy, in the following sections the scenarios without any compensation are only discussed separately if their results differ significantly from *plib\_lnd* and *lib\_lnd*.

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
wht	- 4.9	- 4.9	- 3.7	- 4.4	- 4.4	- 3.1
gro	- 4.8	- 4.8	- 3.1	- 3.8	- 3.7	- 1.8
ngc	- 34.8	- 34.8	- 31.4	- 46.6	- 46.5	- 43.6
olp	- 4.7	- 4.7	- 3.5	- 5.3	- 5.3	- 4.0
met	- 4.5	- 4.5	- 3.6	- 5.8	- 5.8	- 5.0
mil	- 4.7	- 4.7	- 4.2	- 13.7	- 13.7	- 12.2
ofp	- 2.8	- 2.8	- 2.1	5.7	5.7	6.3
opp	0.4	0.4	0.5	1.1	1.1	1.2
mnfcs	1.6	1.6	1.3	2.1	2.1	1.8
svces	0.7	0.7	0.6	0.6	0.6	0.6

Table 3.3:Changes in output in the EU under various policy scenarios<br/>(in percent)

Source: Own calculations.

In scenarios *plib\_00* and *plib\_lnd*, production of wheat and other grains is reduced by about 5 percent. Non-grain crops are reduced even more by 35 percent, which is mainly due to the abolishment of specific subsidies for oilseeds and the price reduction for sugar. Livestock production and food industry products drop slightly between 3 and 5 percent. Other sectors' output rises very little, but it has to be kept in mind that these sectors in the model are very large compared to agriculture and food. Consequently small relative changes might imply large changes in volumes and vice versa. A labor subsidy in *plib\_lab* causes a smaller output reduction in agricultural and food products.

Under a complete liberalization, the output reduction in non-grain crops is even stronger than in the previous scenarios at 44 to 47 percent. The additional drop is caused by the complete liberalization of the sugar sector. For grains the changes are slightly less than under a partial liberalization, since, as already mentioned, after the 1992 CAP reform there was hardly any border protection left and these sectors benefit from the sharp reduction in non-grain crops. The increase in production in other food products is caused by the removal of existing taxation in the reference situation.

# Trade

Due to output changes, trade volumes between the model regions are also altered. The Armington assumption implies changes in exports as well as imports for all products. In order to avoid confusion, only the overall changes in the trade balance for aggregated sectors of the economy are shown, i.e. agriculture, the food industry and other sectors (Figure 3.3).

It is obvious that the net trade position for agriculture worsens significantly in all scenarios. As could be expected, in the case of a complete liberalization this effect is strongest. Net trade in food products is affected only to a minor extent, while other sectors, mainly manufactures, improve their trade position. The sum of the sector trade balances is close to zero which is in accordance with the macroeconomic closure of the model. The current account can only change in proportion to the changes in overall savings and investments.

Figure 3.3: Changes in trade balance in the EU under various policy scenarios (in Mill. 1992 ECU)



Source: Own calculations.

According to the model results, the EU might be able to fulfill WTO requirements with respect to subsidized export quantities in all scenarios. Under *plib\_lab*, the scenario with the smallest export reductions, quantities for crop products fall by - 34 percent (*wht*), - 17 percent (*gro*) and - 75 percent (*ngc*), while milk and meat products are reduced by - 32 and - 38 percent, respectively. All figures are higher (in absolute terms) than the WTO requirements for export quantity reductions (IATRC 1994; AID 1997). However, the results for commodity aggregates in the model cannot simply be compared with real WTO obligations for single products, since WTO rules generally do

not allow aggregation over various commodities. Hence, the model results only allow an approximate judgement in this respect.

#### World market prices

The changes in world market prices that correspond to the model results in output and trade are listed in Table 3.4. Again the results for the scenarios without subsidies and with land subsidies do hardly differ. In *plib\_00* and *plib\_lnd*, price increases occur for agricultural products between 3 and 6 percent, except for non-grain crops where the world market price rises by 12.5 percent. Prices for meat and milk products increase by 7 and 9 percent, respectively. These effects are slightly smaller in *plib\_lab*.

_		- /				
	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
wht	5.6	5.6	3.9	5.8	5.8	4.0
gro	2.8	2.8	1.9	3.3	3.3	2.3
ngc	12.5	12.5	10.9	14.7	14.7	13.1
olp	5.3	5.2	3.3	4.2	4.2	2.3
met	6.9	6.9	5.8	20.1	20.1	18.7
mil	9.0	9.0	7.7	26.7	26.7	25.2
ofp	1.6	1.6	1.3	- 2.6	- 2.6	- 2.9
opp	0.2	0.2	0.2	0.3	0.3	0.2
mnfcs <sup>a</sup>	0.0	0.0	0.0	0.0	0.0	0.0
svces <sup>a</sup>	- 0.1	- 0.1	- 0.1	0.0	0.0	0.0

Table 3.4:Changes in world market prices under various policy scenarios<br/>(in percent)

<sup>a</sup> Minor changes are rounded to 0.0.

Source: Own calculations.

Under a complete liberalization the strongest price effects can be found for meat and milk products. This is caused by the removal of still high protection after the 1992 CAP reform. Prices rise depending on the policy scenario by about 19 to 20 percent for meat and 25 to 27 percent for milk. The price decrease for other food products can be explained by the output increase after abolishment of the initial level of taxation in the database.

#### Welfare

The production and price effects already discussed correspond to changes in resource allocation that have positive welfare impacts within the EU and the world as a whole (Table 3.5). In the GTAP model, the overall change in welfare for a region is calculated as the Equivalent Variation (JUST et al. 1982, Chapter 6). This is possible on the basis of an underlying explicit utility function for each region (HERTEL and TSIGAS 1997, p.35). The major share in global welfare gains from a further CAP reform accrues to the EU itself. Compared to the reference situation the scenario *lib\_lab* is the welfare maximizing option for the EU. In this case, agricultural markets are even less distorted than the rest of the economy and labor is drawn into this sector by the subsidy. In the complete liberalization scenarios, a global welfare gain of about 30.5 billion 1992 ECU is achieved which is about 25 percent higher than under partial liberalization. With the exception of Canada, Japan, and the Former Soviet Union all other model regions gain significantly from CAP liberalization, especially Latin America and Africa, i.e. the Rest-of-the-World region.

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
EU-15	17034	16977	17169	20202	20154	21691
Australia/New Zealand	664	664	560	1621	1621	1490
Canada	108	109	82	- 17	- 17	- 47
USA	924	924	746	1246	1245	1023
Japan	- 105	- 105	- 125	- 1184	- 1184	- 1189
CEC-7	75	75	32	696	695	628
Former Soviet Union	- 215	- 212	- 186	- 200	- 197	- 187
Asia	881	880	744	1019	1019	864
Rest of the World	3204	3209	2614	7080	7083	6244
World total	22571	22521	21634	30463	30418	30517

Table 3.5:Welfare changes (Equivalent Variation in million 1992 ECU) under<br/>various policy scenarios

Source: Own calculations.

#### Factor markets

An important advantage of an AGE model as compared to partial models is perhaps the possibility of tracing factor movements between sectors and consequently factor price changes. Changes in factor use can also explain output and trade effects. Table 3.6 provides an overview of the change in land use in the EU under various scenarios.

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
wht	21.1	21.4	19.9	27.9	28.4	26.8
gro	21.2	21.6	20.6	29.0	29.5	28.5
ngc	- 6.8	- 6.5	- 5.6	- 13.9	- 13.6	- 12.5
olp	14.8	15.1	13.7	19.6	20.0	18.5
opp	29.7	- 33.7	32.8	41.6	- 27.6	44.9

Table 3.6:Changes in land use in the EU under various policy scenarios<br/>(in percent)

Source: Own calculations.

In the case of partial liberalization without a subsidy, land use decreases in non-grain crops and increases in other agricultural sectors. More land is also used in the primary products sector, e.g. in forestry. In scenario *plib\_lnd* land moves out of the primary products sector (- 34 percent) into agriculture, while a subsidy on labor shifts land use in the other direction. The scenarios covering a complete liberalization show a similar pattern, but with stronger changes in land use.

While looking at the percentage changes it has to be mentioned, though, that in the reference situation non-grain crops and livestock products (ngc and olp) account for about 90 percent of land endowment in the EU, since they are aggregates consisting of several products. The primary products sector, on the other hand, has a relatively small share in overall land use. Relatively small percentage changes for ngc in Table 3.6 correspond to comparatively large absolute numbers, and vice versa for opp.

In the simulated scenarios also major shifts in labor use across sectors can be found (Table 3.7). When interpreting these results one has to take into consideration that an AGE model with perfect factor markets by definition always achieves full employment of all factors. Total labor use in agriculture decreases as a consequence of further liberalization. The strongest effects occur for non-grain crops. Although the change in total labor use is reduced through a direct subsidy, still labor moves out of agriculture, on average by about 20 percent in *plib\_lab* (compared to 24 percent in *plib\_00* and *plib\_lnd*) and 27 percent in *lib\_lab* (compared to 31 percent in *lib\_00* and *lib\_lnd*). Moreover, under a partial liberalization there is also a decrease in total labor use in the food industry by about 4 percent, whereas under complete liberalization no change occurs. The reduction in milk and meat products is compensated by other food products.

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
wht	- 7.5	- 7.5	- 4.1	- 7.1	- 7.1	- 3.6
gro	- 7.7	- 7.7	- 3.6	- 6.8	- 6.8	- 2.8
ngc	- 37.5	- 37.5	- 32.5	- 49.3	- 49.3	- 44.9
olp	- 7.1	- 7.1	- 3.5	- 8.1	- 8.1	- 4.5
met	- 9.5	- 9.4	- 9.4	- 14.8	- 14.7	- 13.5
mil	- 4.6	- 4.6	- 4.6	- 13.5	- 13.5	- 13.0
ofp	- 2.6	- 2.6	- 2.6	5.9	5.9	6.5
opp	0.6	0.6	0.5	1.4	1.4	1.3
mnfcs	1.7	1.7	1.4	2.2	2.2	1.9
svces	0.9	0.9	0.7	0.9	0.9	0.7

Table 3.7:Changes in labor use in the EU under various policy scenarios<br/>(in percent)

Source: Own calculations.

Finally, changes in factor prices will be briefly discussed. In Table 3.8 changes in market prices ( $P_m$ ) as well as the perceived producer prices ( $P_p$ ) for land and labor are given.

Table 3.8:Changes in factor prices for land and labor in EU agriculture under<br/>various policy scenarios (in percent)

	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
Land $(P_m)^a$	- 38.4	143.9	- 41.1	- 48.8	102.4	- 51.1
Land $(P_p)^a$	- 44.0	- 43.9	- 46.4	- 53.9	- 53.9	- 55.9
Labor (P <sub>m</sub> )	- 1.4	- 1.4	- 1.4	- 1.4	- 1.4	- 1.1
Labor (P <sub>p</sub> )	- 1.4	- 1.4	- 15.0	- 1.4	- 1.4	- 15.0

<sup>a</sup>  $P_m = market$  price;  $\overline{P_p} = perceived$  producer price. Source: Own calculations.

In the scenarios without any factor subsidies, market prices and perceived producer prices change in the same way, small differences between  $P_m$  and  $P_p$  for land are due to the removal of set-aside requirements. Since output prices are falling after further liberalization the value of marginal product for land also drops in all scenarios. This translates within the model into a decrease in the market price for land, i.e. the land rent. The strongest decrease is about 51 percent in scenario *lib\_lab*. However, a land subsidy causes an increased demand for land in agriculture which can only be met by a very inelastic supply from the small primary products sector.<sup>11</sup> Rising demand together with the imperfect mobility of land drives up the market price heavily in *plib\_lnd* and *lib\_lnd* 

<sup>&</sup>lt;sup>11</sup>About 95 percent of the total endowment of land in the model belongs to the agricultural sector and is therefore eligible for the subsidy.

as shown in Table 3.8. On the other hand, the land subsidy effectively lowers the perceived producer price such that the overall change in  $P_p$  is very close to the scenarios without any subsidies. This also explains the fact that there are hardly any additional output effects in *plib\_lnd* and *lib\_lnd* as compared to *plib\_00* and *lib\_00* (Table 3.3).

The substitutability between primary factors also affects the demand for land and consequently the price changes. In the GTAP database, the default value for the elasticity of substitution between primary factors in agriculture is 0.56. A sensitivity analysis has been conducted in order to evaluate the influence of this parameter on the land price. When the elasticity of substitution was increased to 0.8 the market price for land in *plib\_lnd* rose by 182 percent. In the opposite case, when the elasticity was set at 0.3, the price increase was 67 percent. Apparently, the model results are fairly sensitive with respect to this parameter in this specific setting. In any case, the simulation results support the theoretical effects that were discussed earlier: a high proportion of the land subsidy is transferred to land-owners who benefit from higher market prices.

Labor, on the other hand, can move freely between sectors in the model. Hence, in all scenarios the equilibrium price is only slightly below the reference situation. Since labor supply for agriculture is almost perfectly elastic and therefore the market price is almost fixed, a labor subsidy of 14 percent is fully translated into a lower producer price for labor. However, the assumption of perfect labor mobility is probably not very realistic in agriculture and the results might be affected if labor were more sector specific.

## 3.7 Discussion and Further Implications

The simulation results support the view that after the CAP reform in 1992 there is still considerable potential for further welfare gains from EU agricultural policy reform, especially in the areas of non-grain crops and animal products. In case of complete liberalization of the CAP, production and exports fall quite heavily whereas imports are rising. For meat and milk products world market prices would increase by 20 to 27 percent. Global welfare gains range from about 22 billion ECU under partial liberalization to about 31 billion ECU under complete liberalization, even though the scenarios covered in this paper only describe unilateral policy reform on the side of the EU. However, the GTAP model only calculates the changes in overall regional welfare, but it does not provide a specific indicator for changes in producer income such as

producer surplus. Implications of the presented policy scenarios for farm income were analyzed in the study by KIRSCHKE et al. (1997), based on linear programming models on the farm level for Germany. The authors conclude that even under a partial liberalization many farms could not survive without any compensation. Even in more productive locations most farms run into cash flow problems.

In some respect the subsidy payments proposed in this paper are less distortionary than current payments, as they are related to land or labor and discriminate less between specific agricultural products. However, a land subsidy is certainly biased towards crops whereas a labor subsidy is more favorable for livestock production. Moreover, if factor subsidies are only paid in the case of actually occurring production, there are significant shifts of resources from the rest of the economy into agriculture, especially in the case of a labor subsidy.

In summary, there are only minor differences in the model results between the scenarios with land and labor subsidies. Land as a production factor is almost exclusively used in agriculture. Changes in supply are only possible through reduced set-aside and, to a minor extent, shifting land from other primary products (e.g. forestry) into farming. Although the subsidy lowers the perceived producer price for land, increased demand also causes strong increases in the market price for land. Hence, the subsidy on land is partly transferred to the owners of land. To what extent the increases in land rents can be transferred from farmers to land-owners depends on the regulatory details of the policy measure. In any case, it cannot be excluded that new farmers would face barriers to entry due to higher land rents as a consequence of the subsidy. Labor use in agriculture is heavily reduced in all scenarios discussed in this paper. Although the movement of labor force out of agriculture slows down if labor is directly subsidized, output changes are only slightly affected compared to the other scenarios.

For both kinds of government support presented here, the details of regulation and administration have to be further discussed and analyzed, i.e. upper bounds related to a specific reference year or gradual reduction over time. For these purposes farm-related models would probably be more appropriate than an AGE approach (e.g. BALMANN et al. 1998). Nevertheless, the model results in this paper provide some initial insights into the medium-term effects of the proposed policy instruments.

Based on the model calculations the likely effects on the EU budget can be estimated (Table 3.9). Since the GTAP model does not explicitly provide government expenditures and the tariff equivalents in the database also include non-tariff barriers, some side-calculations have to be done in order to relate the model results to the real EU budget in the reference situation. Therefore, the relative changes in government intervention from the model calculations are applied to the official data on the EU budget in 1996. With respect to other budget expenditures that are not directly affected by the calculations, e.g. market interventions and structural funds, some additional assumptions are necessary as to how they change under the various scenarios. These are partly taken from KIRSCHKE et al. (1997).

The biggest share in budget savings results from the removal of product-related payments in all scenarios as well as the abolishment of export subsidies in the case of a complete liberalization of the CAP. On the other hand, new outlays arise for direct factor payments. In scenarios *plib\_lnd* and *plib\_lab*, budget savings sum up to about 7 billion ECU, i.e. 17 percent of current expenditures in 1996. In the case of a complete liberalization with a labor or land subsidy, savings would be at about 17 billion ECU which is equivalent to 42 percent of the current budget.

	Status quo 1996	plib_00	plib_lnd	plib_lab	lib_00	lib_lnd	lib_lab
Direct payments <sup>a</sup>	18 677						
Export subsidies	7 060	3 774	3 775	3 925			
Import tariffs	- 864	- 1 191	- 1 191	- 1 119			
Land subsidies			16 511			16 511	
Labor subsidies				16 779			16 779
Subtotal	24 873	2 582	19 095	19 585		16 511	16 779
Other expenditures <sup>b</sup>	19 174	17 257	17 257	17 257	8 300	8 300	8 300
Other revenues <sup>c</sup>	- 1 287	- 644	- 644	- 644			
Total	42 760	19 195	35 708	36 198	8 300	24 811	25 079

Table 3.9:Budget effects of various policy scenarios in the EU<br/>(in Mill. 1992 ECU)

<sup>a</sup> Compensation, set-aside and animal payments from the 1992 CAP reform.

<sup>b</sup> Market intervention and structural funds.

<sup>c</sup> Sugar levies.

Source: KIRSCHKE et al. (1997); EUROPEAN COMMISSION (1997a); own calculations.

If all the conditions and restrictions surrounding a Common Agricultural Policy in the future are taken into account, it is very difficult to come up with consistent policy prescriptions in favor of a specific scenario on the basis of the presented model results. The budget savings effect is largest in case of a complete liberalization. However, political viability of this option within the EU seems to be questionable at least. With regard to meeting current WTO obligations the model results indicate that even partial liberalization by the EU would be sufficient. Whether or not factor subsidies would be WTO compatible remains unclear and depends on the specific policy design.

Two arguments in favor of a land subsidy can be mentioned: very small output enhancing effects and, most likely, easier administration. In addition to that, a land subsidy seems to make sense with respect to the situation in potential new EU member countries in Central and Eastern Europe. In case of an Eastern enlargement, regional differentiation of subsidy levels should probably be considered and could be easily implemented. Finally, it can be assumed that environmental standards related to agriculture, once they are introduced, could be easily linked to a direct subsidy on agricultural land. The payment could be supplemented on a regional level if certain location-specific environmental criteria are met by farmers.

The model simulations covered in this paper are certainly incomplete and there is wide scope for improvement and further analysis. First, the assumption of perfect mobility of labor between agriculture and the rest of the economy can be questioned, since this is right at the core of the debate about farm income disparity in agriculture. Modeling restricted labor mobility could be a starting point for further simulations. This would certainly modify the implications of a labor subsidy. A further step would be the simulation of an EU Eastern enlargement under the proposed policy options.

# 3.8 References

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#### Appendix A-3.1 Derivation of the Theoretical Effects of an Input Subsidy

The numerical effects of an input subsidy as illustrated in Figure 3.1 can be derived using a model of an agricultural sector with one output and two inputs. The derivations are explained in detail in GARDNER (1990, Chapter 4). Although this model is very simple compared to the AGE model used for policy simulations in this paper, the principal reactions caused by an input subsidy are similar.

The structure of the model is given by the following six equations:

(1)x = f(a,b)Production function (2)  $f_a P_x = P_a$ Value of marginal product for a = factor price for a $f_h P_r = P_h$ Value of marginal product for b = factor price for b(3)  $a = g(P_a)$ (4) Factor supply for *a*  $b = h(P_{h})$  Factor supply for b (5) (6)  $x = D(P_x)$ Product demand

with output quantity x and price  $P_x$ , input quantities a and b and prices  $P_a$  and  $P_b$ , and partial differentials  $f_a$  and  $f_b$ .

The underlying assumptions are perfect competition in input and output markets, profit maximizing producers and identical firms throughout. The production function is assumed to be twice differentiable and concave. This implies a linear homogeneous industry production function. The elasticities of x with respect to inputs a and b are equal to their factor shares and the value of output equals the sum of factor receipts  $(xP_x=aP_a+bP_b)$ . If an equilibrium exists one can find it in the model by solving the above system of six equations in six endogenous variables.

In order to derive comparative static effects the above system is totally differentiated:

(1') 
$$dx = f_a da + f_b db$$

(2') 
$$dP_a = f_{aa}P_xda + f_{ab}P_xdb + f_adP_x$$

(3') 
$$dP_b = f_{bb}P_xdb + f_{ba}P_xda + f_bdP_x$$

$$(4') \qquad da = g_a dP_a$$

$$(5') \qquad db = h_b dP_b$$

$$(6') \qquad dx = D_x dP_x$$

with single subscripts denoting first derivatives and double subscripts denoting second derivatives.

The total derivatives can be converted into percentage changes and rearranged into the following equations:

(1") 
$$\frac{dx}{x} = K_a \frac{da}{a} + K_b \frac{db}{b}$$

(2") 
$$\frac{dP_a}{P_a} = -\frac{K_b}{\sigma}\frac{da}{a} + \frac{K_b}{\sigma}\frac{db}{b} + \frac{dP_x}{P_x}$$

(3") 
$$\frac{dP_b}{P_b} = -\frac{K_a}{\sigma}\frac{db}{b} + \frac{K_a}{\sigma}\frac{da}{a} + \frac{dP_x}{P_x}$$

(4") 
$$\frac{da}{a} = e_a \frac{dP_a}{P_a}$$

(5") 
$$\frac{db}{b} = e_b \frac{dP_b}{P_b}$$

(6") 
$$\frac{dx}{x} = \eta \frac{dP_x}{P_x}$$

with  $K_a$  and  $K_b$  being the relative shares of a and b in total costs,  $\sigma$  the Allen elasticity of factor substitution,  $e_a$  and  $e_b$  the elasticities of factor supply and  $\eta$  the elasticity of product demand.

In order to analyze an input subsidy on factor *a* an exogenous policy instruments needs to be introduced. In equations (1") through (6")  $\left(\frac{dP_a}{P_a} + \frac{dt_a}{t_a}\right)$  is substituted for  $\frac{dP_a}{P_a}$ . The exogenous variable  $t_a$  is the policy "wedge" between price and marginal cost on the input market *a*. Finally, equations (1") through (6") can be divided by the change in the

policy instrument  $\frac{dt_a}{t_a}$  and the equations can be solved for the endogenous variables. This yields solutions in elasticity form, i.e. the percentage change of an endogenous variable caused by a percentage change in the policy instrument.

(1''') 
$$\frac{dx}{x} / \frac{dt_a}{t_a} = \frac{K_a \eta e_a(e_b + \sigma)}{D}$$

(2"") 
$$\frac{dP_a}{P_a} / \frac{dt_a}{t_a} = \frac{e_a(e_b + K_a\sigma - K_b\eta)}{D}$$

(3''') 
$$\frac{dP_b}{P_b} / \frac{dt_a}{t_a} = \frac{K_a e_a(\sigma + \eta)}{D}$$

(4''') 
$$\frac{da}{a} / \frac{dt_a}{t_a} = \frac{e_a \sigma \eta - e_b (K_b \sigma - K_a \eta)}{D}$$

(5''') 
$$\frac{db}{b} / \frac{dt_a}{t_a} = \frac{K_a e_a e_b (\sigma + \eta)}{D}$$

(6''') 
$$\frac{dP_x}{P_x} / \frac{dt_a}{t_a} = \frac{K_a e_a (e_b + \sigma)}{D}$$

with  $D = e_a e_b - \eta (\sigma + K_a e_b + K_b e_a) + \sigma (K_a e_a + K_b e_b)$ .

With given values for the parameters  $K_a$ ,  $K_b$ ,  $e_a$ ,  $e_b$ ,  $\eta$  and  $\sigma$ , the comparative-static effects of a change in the input subsidy can now be calculated. In the "normal" case one would assume that  $e_a$ ,  $e_b$  and  $\sigma$  are positive, and  $\eta$  is negative.

#### Appendix A-3.2 GEMPACK Command Files for Policy Scenarios

This appendix lists the command files for implementing the policy scenarios discussed in Section 3.3 in the GEMPACK modeling software. The first file (*plib\_00.cmf*) is completely provided, while the details for the other command files are only given where they differ from the first scenario.

```
_plib_00.cmf
! This GEMPACK command file simulates partial liberalization without
! compensation
                                                                !
1
! Which model
auxiliary files = tp1010eu;
! Solution method information.
method = euler ;
steps = 10 20 30;
! files
file gtapSETS = set3-03a.har;
file gtapPARM = par3-03.dat;
file gtapDATA = eu3int1.upd;
! The data file "eu3int1.upd" includes EU-12 enlargement to EU-15 and
! implementation of the 1992 CAP reform from previous simulations
! Next is necessary if reusing pivots is to succeed in multistep simulation
iz1 = no;
Equations File = TP3-03 ;
         model = TP1010eu ;
         version = 1 ;
         Identifier = GTAPEU15.TAB with 10x10 data ;
Verbal Description =
*****
Model TP1010eu
Experiment "plib_00": Partial liberalization without compensation
Solution Method: euler 10 20 30
1
! Closure rule
1
Exogenous pop
         psave
         saveslack govslack incomeslack
         profitslack endwslack tradslack cgdslack
         ao af afe ava atr
         to tms txs tx tm tf
         qo(endw_comm,reg)
                              ;
Rest Endogenous ;
! Shocks for plib_00
! NOTE: "select from file xxx" in all cases means complete reduction from
! initial values
! Removal of set-aside requirements (These have been introduced before in
! the 1992 CAP reform)
Shock qo("land", EU15) = uniform 5.26 ;
```

```
Shock tf("land", "wht", EU15) = select from file tfeu15a.shk ;
Shock tf("land", "gro", EU15) = select from file tfeu15a.shk ;
Shock tf("land", "ngc", EU15) = select from file tfeu15a.shk ;
! Cereals
Shock to("wht", EU15) = select from file toeu15a.shk ;
Shock to("gro", EU15) = select from file toeu15a.shk ;
! Oilseeds
Shock to("ngc", EU15) = select from file toeu15a.shk ;
! Sugar
Shock txs("ngc", EU15, NON_EU15) = uniform -10 ;
Shock tms("ngc", NON_EU15, EU15) = uniform -10 ;
! Beef
Shock txs("met", EU15, NON_EU15) = uniform -10 ;
Shock tms("met", NON_EU15, EU15) = uniform -10 ;
! Milk
Shock txs("mil", EU15, NON_EU15) = uniform -10 ;
Shock tms("mil", NON_EU15, EU15) = uniform -10 ;
! Animal premia
Shock to("olp", EU15) = select from file toeu15a.shk ;
!
! Output File Specification (they are experiment dependent)
1
Save Environment File
                        plib_00 ;
Solution File = plib_00 ;
                 File = plib_00.LOG ;
Log
1
! Updated data files
Updated file gtapSETS = set3-03a.upd;
Updated file gtapPARM = par3-03.upd;
Updated file gtapDATA = plib_00.upd;
1
Display file = tp3-03.dis ;
!
! Other Options
1
Extrapolation accuracy file = YES ;
CPU = yes ;
                      _____End of Command file.___
```

!\_\_

\_plib\_lnd.cmf\_ 1 ! This GEMPACK command file simulates partial liberalization with land ! subsidy. 1 1 [...] ! Shocks for plib\_lnd ! NOTE: "select from file xxx" in all cases means complete reduction from ! initial values ! Removal of set-aside requirements (These have been introduced before in ! the 1992 CAP reform) PLUS land subsidy Shock qo("land", EU15) = uniform 5.26 ; Shock tf("land", "wht", EU15) = uniform -79.17; Shock tf("land", "gro", EU15) = uniform -79.17; Shock tf("land", "ngc", EU15) = uniform -78.26; Shock tf("land", "olp", EU15) = uniform -75; ! Cereals Shock to("wht", EU15) = select from file toeu15a.shk ; Shock to("gro", EU15) = select from file toeu15a.shk ; ! Oilseeds Shock to("ngc", EU15) = select from file toeu15a.shk ; ! Sugar Shock txs("ngc", EU15, NON\_EU15) = uniform -10 ; Shock tms("ngc", NON\_EU15, EU15) = uniform -10 ; ! Beef Shock txs("met", EU15, NON\_EU15) = uniform -10 ; Shock tms("met", NON\_EU15, EU15) = uniform -10 ; ! Milk Shock txs("mil", EU15, NON\_EU15) = uniform -10 ; Shock tms("mil", NON\_EU15, EU15) = uniform -10 ; ! Animal premia Shock to("olp", EU15) = select from file toeu15a.shk ; [...] \_\_\_\_\_End of Command file.\_\_ 1

\_!

!

\_!

!

\_plib\_lab.cmf\_ 1 ! This GEMPACK command file simulates partial liberalization with labor ! subsidy. ! 1 [...] ! Shocks for plib\_lab ! NOTE: "select from file xxx" in all cases means complete reduction from ! initial values ! Removal of set-aside requirements (These have been introduced before in ! the 1992 CAP reform) Shock qo("land", EU15) = uniform 5.26 ; Shock tf("land", "wht", EU15) = select from file tfeu15a.shk ; Shock tf("land", "gro", EU15) = select from file tfeu15a.shk ; Shock tf("land", "ngc", EU15) = select from file tfeu15a.shk ; ! Cereals Shock to("wht", EU15) = select from file toeu15a.shk ; Shock to("gro", EU15) = select from file toeu15a.shk ; ! Oilseeds Shock to("ngc", EU15) = select from file toeu15a.shk ; ! Sugar Shock txs("ngc", EU15, NON\_EU15) = uniform -10 ; Shock tms("ngc", NON\_EU15, EU15) = uniform -10 ; ! Beef Shock txs("met", EU15, NON\_EU15) = uniform -10 ; Shock tms("met", NON\_EU15, EU15) = uniform -10 ; ! Milk Shock txs("mil", EU15, NON\_EU15) = uniform -10 ; Shock tms("mil", NON\_EU15, EU15) = uniform -10 ; ! Animal premia Shock to("olp", EU15) = select from file toeu15a.shk ; ! Labor subsidy Shock tf("labor", "wht", EU15) = uniform -33 ; Shock tf("labor", "gro", EU15) = uniform -33; Shock tf("labor", "ngc", EU15) = uniform -33; Shock tf("labor", "olp", EU15) = uniform -33; [...] \_\_\_\_\_End of Command file.\_\_\_

\_lib\_00.cmf\_ 1 \_! ! This GEMPACK command file simulates complete liberalization without ! compensation. ! ! 1 [...] ! Shocks for lib\_00 ! NOTE: "select from file xxx" in all cases means complete reduction from ! initial values ! Removal of set-aside requirements (These have been introduced before in ! the 1992 CAP reform) Shock qo("land", EU15) = uniform 5.26; Shock tf("land", "wht", EU15) = select from file tfeu15a.shk ; Shock tf("land", "gro", EU15) = select from file tfeu15a.shk ; Shock tf("land", "ngc", EU15) = select from file tfeu15a.shk ; ! Complete liberalization in all agriculture and food sectors Shock to(AG\_FOOD, EU15) = select from file toeu15a.shk ; Shock txs(AG\_FOOD, EU15, NON\_EU15) = select from file txseu15a.shk ; Shock tms(AG\_FOOD, NON\_EU15, EU15) = select from file tmseu15a.shk ; [...] \_\_\_\_\_End of Command file.\_\_\_ ! \_lib\_lnd.cmf\_ ! This GEMPACK command file simulates complete liberalization with land ! subsidy. ! - ! 1 [...] ! Shocks for lib\_lnd ! NOTE: "select from file xxx" in all cases means complete reduction from ! initial values ! Removal of set-aside requirements (These have been introduced before in ! the 1992 CAP reform) PLUS land subsidy Shock qo("land", EU15) = uniform 5.26 ; Shock tf("land", "wht", EU15) = uniform -79.17; Shock tf("land", "gro", EU15) = uniform -79.17; Shock tf("land", "ngc", EU15) = uniform -78.26; Shock tf("land", "olp", EU15) = uniform -75; ! Complete liberalization in all agriculture and food sectors Shock to(AG\_FOOD, EU15) = select from file toeu15a.shk ; Shock txs(AG\_FOOD, EU15, NON\_EU15) = select from file txseu15a.shk ; Shock tms(AG\_FOOD, NON\_EU15, EU15) = select from file tmseu15a.shk ; [...] \_\_\_\_\_End of Command file.\_\_\_ !

\_!

!

\_lib\_lab.cmf\_ 1 ! This GEMPACK command file simulates complete liberalization with labor ! subsidy. ! 1 [...] ! Shocks for lib\_lab ! NOTE: "select from file xxx" in all cases means complete reduction from ! initial values ! Removal of set-aside requirements (These have been introduced before in ! the 1992 CAP reform) Shock qo("land", EU15) = uniform 5.26; Shock tf("land", "wht", EU15) = select from file tfeu15a.shk ; Shock tf("land", "gro", EU15) = select from file tfeu15a.shk ; Shock tf("land", "ngc", EU15) = select from file tfeu15a.shk ; ! Complete liberalization in all agriculture and food sectors Shock to(AG\_FOOD, EU15) = select from file toeu15a.shk ; Shock txs(AG\_FOOD, EU15, NON\_EU15) = select from file txseu15a.shk ; Shock tms(AG\_FOOD, NON\_EU15, EU15) = select from file tmseu15a.shk ; ! Labor subsidy Shock tf("labor", "wht", EU15) = uniform -33 ; Shock tf("labor", "gro", EU15) = uniform -33 ; Shock tf("labor", "ngc", EU15) = uniform -33 ; Shock tf("labor", "olp", EU15) = uniform -33 ;

[...]

\_\_\_\_\_End of Command file.\_\_\_\_\_

# 4 Implications of a European Union Eastern Enlargement under a New Common Agricultural Policy

# 4.1 Introduction

The integration of several Central European countries (CEC) will probably be one of the biggest challenges for the European Union (EU) in the near future. In contrast to earlier enlargement rounds there are not only considerable differences between the EU-15 and potential new members in terms of economic development, but also with respect to the political environment in the transition process. While ten CEC have formally applied for membership, the EU recently announced five of them as being the first candidates for integration, i.e. Estonia, Czech Republic, Hungary, Poland, and Slovenia.

For several reasons the agriculture and food sector could become a major stumbling block on the way towards an enlarged EU. The potential new members have a higher share of agriculture in the gross domestic product (GDP), a much higher proportion of agricultural labor force, and household expenditures on food which are considerably above EU levels (OECD 1996; WORLD BANK 1996). Hence, protection measures and transfers under the Common Agricultural Policy (CAP) will have an important impact on the new members during the process of enlargement.

There is almost no doubt that the CAP will have to change prior to the integration of any CEC. The pressure for change is already indicated by the EU Commission in the Agenda 2000 (EUROPEAN COMMISSION 1997a). As a consequence of the Uruguay Round under the General Agreement on Tariffs and Trade (GATT), the EU faces constraints on the level of agricultural border protection. Depending on the level of world market prices in the near future, upper limits for subsidized exports and the total amount of export subsidies could become binding and force the EU to cut down overall production in grains, sugar, beef, and dairy products (EUROPEAN COMMISSION 1997a, p.29). So-called "blue box" measures under the regulations of the World Trade Organization (WTO), e.g. product-related compensation payments that were introduced in the 1992 CAP reform, will also be challenged in the upcoming WTO round (USDA 1997a).

With regard to new members it is debated whether or not they should be eligible for all benefits under the CAP. Since most of the direct payments currently in operation in

agriculture were introduced as a compensation for earlier price cuts within the EU-15, it could be argued that there is no need for compensation in the CEC. More importantly, income distribution between agriculture and other sectors would be heavily distorted if farmers in the CEC received the same nominal subsidy payments as currently available in the EU-15. On the other hand, so far all agricultural policy measures are applied uniformly throughout the EU and it might be difficult to establish a "two-class" system where farmers in some countries are subsidized more than in others. The EU Commission itself indicates that there will be a single agricultural policy regime for old as well as new members, although possibly only after a longer transition period (AGRA EUROPE 17/97, p.E7). However, the transfer of current protection levels to the CEC might not be possible for other reasons. From the GATT Uruguay Round the CEC face limits regarding border protection which are much lower than current EU levels. If they would join the EU without major changes to the CAP, their WTO obligations would certainly be violated (TWESTEN 1998).

Finally, the discussion about financing the CAP in general is another crucial issue. It can be assumed that the CEC will be net recipients with respect to the EU budget, at least in the first years of membership. Hence, the financial impact of a potential enlargement will become a crucial issue during the upcoming negotiations. Already now the EU agricultural guideline sets a limit to the agricultural budget such that expenditures must not increase by more than 74 percent of the growth rate of GDP (TANGERMANN 1997, p.14). It is unlikely that the EU will raise this rate in the near future.

There is a broad discussion and a variety of proposals for further developing the CAP. In the Agenda 2000, the EU Commission recently proposed intervention price cuts for grains, milk, and beef, combined with per-animal compensation payments, an extension of the milk quota until 2006, and set-aside rates fixed at zero percent. Uniform per-hectare payments for grains, oilseeds and voluntary set-aside will be provided. Going far beyond this, several agricultural economists have suggested further decoupling of agricultural income support from production including the introduction of direct factor subsidies (WISSENSCHAFTLICHER BEIRAT 1997; KIRSCHKE et al. 1997, 1998). The debate over changes in EU agricultural policy makes the CAP a "moving target" for the new members and difficult to adjust their own policies towards the CAP in preparation for joining the EU.

Several studies have been conducted analyzing a potential EU Eastern enlargement in a partial equilibrium framework (e.g. TANGERMANN et al. 1994; ANDERSON and TYERS 1995; EUROPEAN COMMISSION 1995; MAHÉ et al. 1995). While partial equilibrium models are usually quite detailed in the commodity disaggregation they do not account for linkages to other sectors of the economy through factor markets and intermediate input use.<sup>1</sup> In the case of the CEC where agriculture has a significant share in GDP and trade this becomes even more important. In this paper, the EU enlargement is analyzed using a multi-regional AGE model which was developed by the Global Trade Analysis Project (GTAP). The GTAP model and the database have been used for this purpose in other studies (FRANDSEN et al. 1996; FRANCOIS 1997; BROCKMEIER et al. 1997; HERTEL et al. 1997; SWAMINATHAN 1997). This paper adds to these studies a different set of policy options under the CAP and an explicit modeling of the development path up the point of enlargement. Different scenarios for the integration of Central European countries into the EU are analyzed with a uniform payment on agricultural land as the major policy instrument under a modified CAP. In addition to various policy options, two possible growth scenarios up to the date of enlargement are taken into consideration.

In the next section, the policy scenarios are described in detail followed by the model description and empirical implementation. Selected simulation results are provided in Section 4.4 covering growth in output and trade as well as changes in domestic prices and factor use after EU enlargement. Trade creation and trade diversion effects of the enlargement are discussed and some budgetary consequences are provided. The paper concludes with a summary and outlook regarding further modeling options.

# 4.2 Policy Scenarios for a European Union Enlargement

In modeling a potential Eastern enlargement of the EU with a focus on agriculture and food the following questions have to be answered:

- 1. Which of the Central European countries will be the first new members of the EU?
- 2. Will there be any changes to the CAP prior to enlargement, and will all policy measures be fully extended to the new members?

<sup>&</sup>lt;sup>1</sup> BROCKMEIER et al. (1997) provide an overview of these studies and discuss the advantages of general vs. partial equilibrium approaches for the analysis of EU integration of transition countries.

3. When will the enlargement actually occur, and how will the model regions develop up to this point?

Although the EU recently announced the first five candidates for enlargement negotiations, in this paper a simultaneous integration of a group of seven countries from Central Europe is analyzed, i.e. Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia, which will be called CEC-7. The reason for choosing this group is mainly technical due to the regional disaggregation of the model database.

With regard to the second question it can be assumed that the EU will, due to WTO obligations and budgetary restrictions, further liberalize its agricultural policies in the future. This might even become a precondition for enlargement, since tariff bindings for the CEC under the WTO are generally much below those of the EU-15, and any new member country will have free access to agricultural markets and policies within the EU (TANGERMANN 1997, p.14). From the variety of proposals for further CAP reform<sup>2</sup> in this paper a uniform subsidy on agricultural land is chosen as the main policy instrument under a modified CAP. This was also considered as an important option in recent studies in the context of German agriculture (WISSENSCHAFTLICHER BEIRAT 1997; KIRSCHKE et al. 1997, 1998). Land subsidies may not only be seen as a means of income compensation due to price liberalization, they also could be easily linked to achievement of certain environmental standards. In modeling the EU enlargement a complete and immediate transfer of all agricultural policy measures into the CEC-7 is assumed.<sup>3</sup>

Policy options covered in this paper comprise partial as well as complete liberalization of the CAP. *Partial liberalization* includes the abolishment of animal payments and compensation payments for crops as well as the compulsory set-aside program. Border protection for sugar, milk and beef is reduced by 10 percent. Production quotas and other market regulations remain in place. With respect to changes in border protection this scenario is similar to the Agenda 2000 as mentioned above. However, a uniform land subsidy is substituted for the variety of direct payments for crops and livestock in the Agenda. It can be assumed, as a side-effect, that this will also lead to lower

<sup>&</sup>lt;sup>2</sup> See KIRSCHKE et al. (1997) for an overview.

<sup>&</sup>lt;sup>3</sup> In this paper it has been abstracted from the fact that introduction of the CAP in CEC will probably have to provide for an adjustment period of several years. For example, BANSE and MÜNCH (1997) model an integration period between the years 2003 and 2007.

administrative costs. The scenario of *complete liberalization* implies the abolishment of all border protection measures in agriculture and food, no quota restrictions for milk and sugar as well as the removal of all product-related compensation payments. In addition, the same uniform land subsidy is introduced.

With respect to the third question, the actual date of enlargement, the integration of the CEC-7 is assumed to occur at once in the year 2005. In order to come up with realistic reference scenarios for the actual enlargement, the model database was updated prior to integration of the CEC-7 into the EU. However, the general economic development until the year 2005 is difficult to forecast, especially in the Central European transition countries. Slovenia and Poland lately achieved annual GDP growth rates between 4 and 7 percent (RYAN and JONES 1997), but it is questionable whether they can sustain this development in the near future. Another question is whether countries like Bulgaria and Romania will be able to catch up in the process of economic and political transition.

Taking these uncertainties into account four counterfactual reference situations have been constructed for the actual enlargement in 2005. They differ with respect to economic growth in the CEC-7 and further reform of the CAP in the EU-15. For the CEC-7, the options are either a moderate growth rate of GDP close to projections for the EU-15, or a faster growth rate more in line with experiences from the "tiger economies" in South East Asia. Expected growth rates for other regions in the model are the same throughout the scenarios. Table 4.1 provides an overview of the enlargement scenarios covered in this paper.

EU Agricultural Policy $\rightarrow$	Partial liberalization	Complete liberalization
$\downarrow$ Growth in CEC-7		
slow	plib_s	lib_s
fast	plib_f	lib_f

 Table 4.1:
 Possible scenarios for an EU integration of the CEC-7 in 2005

# 4.3 Implementation of the Scenarios

## Model Structure and Aggregation

A multi-region AGE model seems appropriate for the analysis in this paper. It does not only cover various agricultural and food sectors, but traces the links to other sectors of the economy including effects on international trade. The GTAP model provides a flexible structure for an AGE analysis of problems in international trade. From the database a maximum of 32 regions and 37 commodities can be aggregated according to the problem at hand.<sup>4</sup> The model aggregation used here covers 10 regions with 10 sectors (Table 4.2). Each sector only produces one output.

On the production side of all sectors the model has a so-called nested structure. Land, labor and capital as the primary factors of production are combined to a primary aggregate input using a constant elasticity of substitution (CES) function. The same applies to domestic and imported intermediate inputs which are combined to an intermediate aggregate input. The two aggregates then contribute to final output via a Leontief function. In the standard model, capital and labor are perfectly mobile *between* sectors, but the total endowment with these factors *within* a region is fixed.

Model regions	Model sectors					
EU-12	Agriculture:	Wheat	(wht)			
Austria/Finland/Sweden		Other grains	(gro)			
CEC-7		Non-grain crops	(ngc)			
Australia/New Zealand		Livestock products	(olp)			
Canada	Food Industry:	Meat products	(met)			
USA		Milk products	(mil)			
Japan		Other food products	(ofp)			
Former Soviet Union (FSU)	Other Sectors:	Manufactures	(mnfcs)			
Asia		Services	(svces)			
Rest of the World <sup>a</sup>		Primary products <sup>b</sup>	(opp)			

Table 4.2:	Model regions and sectors
------------	---------------------------

<sup>a</sup> Mainly Latin America and Africa.

<sup>b</sup> Mainly Forestry, Fishery, Mining and Energy.

<sup>&</sup>lt;sup>4</sup> A detailed description of the GTAP modeling framework is given by HERTEL and TSIGAS (1997) or at the internet site http://www.purdue.edu/gtap. The version 3 database is described in MCDOUGALL (1997).

Land is only used in primary agriculture and in the other primary products (*opp*) sector, while mobility of land between these sectors is limited by an elasticity of transformation. Private demand is modeled by a constant-difference-in-elasticities (CDE) function which is more flexible than the CES function and allows for differences in price and income responsiveness of demand in different regions depending on the level of development and consumption patterns (HERTEL and TSIGAS 1997, p.26).

Main assumptions of the standard model are perfect competition on all markets as well as profit and utility maximizing behavior of producers and consumers, respectively. In modeling international trade flows, the so-called Armington assumption is applied (ARMINGTON 1969). It is assumed that there is product differentiation by regions. This implies that for a certain product trade flows between two regions can always go in either direction at the same time and there is no *net* trade flow. The Armington assumption fits nicely with regularly observed discrepancies between world market prices for the same commodity at different locations. The change in world market prices in GTAP is calculated as a weighted average price index using bilateral trade flows as weights. However, the Armington assumption has also been criticized by many authors as it is not very flexible and does not endogenize aspects of imperfect competition and industrial organization into international trade. But it still seems to be a reasonable compromise as detailed information on the competitive situation for various sectors is currently not available on a global basis (HERTEL and TSIGAS 1997, p.21-22). The macroeconomic closure of the model is accomplished by a "global bank" which assures an equilibrium of savings and investments between the model regions. In the standard closure used here, the regional share in global investment is fixed. This closure rule is basically neoclassical, but it allows for some adjustment in the mix of investment on a regional level (HERTEL and TSIGAS 1997, p.28-30). The model is solved using the GEMPACK software package (HARRISON and PEARSON 1996).

The GTAP project has developed a comprehensive database using information from numerous international sources (MCDOUGALL 1997). The base year for the data is 1992. However, for further development of the CAP the reference scenario should be the situation in 1996/97 when the changes of the 1992 reform were supposed to be fully implemented. In order to update the database for the simulations in this paper, the 1992 policy changes were implemented in the EU-12, i.e. price decreases for grains, oilseeds, protein seeds, and meat products, in connection with compulsory set-aside and direct

compensation payments. Furthermore, by integrating Austria, Finland and Sweden the current EU-15 was created prior to the simulations of further enlargement to the East.

## Modeling the Development Period until the Year 2005

In order to update the database and create a realistic base scenario for the enlargement year 2005 the general economic development of the model regions have to be forecast. For this it would be necessary to have exogenous estimates on population growth and commodity specific changes in total factor productivity (TFP) for all regions. Since information on TFP changes by commodity is not available the rates of technical change have to be derived endogenously in the model by applying a methodology first presented by GEHLHAR et al. (1994).<sup>5</sup> Exogenous forecasts for several macroeconomic indicators, i.e. growth of GDP, growth of population and labor force, and capital accumulation are used as target values, and then the model is solved by making the technical change parameters endogenous. Thus, TFP changes for every model region can be derived according to the exogenous assumptions about overall economic development until 2005. Moreover, overall economic growth is disaggregated into the equivalent sector-specific changes within the model regions.<sup>6</sup>

Table 4.3 provides macroeconomic forecasts used for calculating the TFP changes in the development period until 2005. For the region CEC-7 two different options are assumed with respect to economic growth, a slow scenario with annual GDP growth at about 3 percent and a fast scenario with 6 to 7 percent.<sup>7</sup>

<sup>&</sup>lt;sup>5</sup> This method was also used by FRANDSEN et al. (1996) for modeling an EU enlargement in 2005.

<sup>&</sup>lt;sup>6</sup> Here only uniform rates of technical change throughout all sectors in one region have been calculated. This could certainly be refined if more information was available on sector-specific rates of technical change. For example, FRANDSEN et al. (1996) assume higher rates of technical change in agriculture than in the rest of the economy. They set agricultural rates of technical change exogenously and let the other sectors adjust accordingly.

<sup>&</sup>lt;sup>7</sup> A growth rate between 6 and 7 percent is certainly a strong assumption, especially as the CEC group is very heterogeneous and growth might not be sustained over several years. Hence, this option should be seen as an upper bound for the transition countries.

	CEC-7 slow	CEC-7 fast	EU-15	FSU	AUS/ NZ	CAN	USA	JAP	ASIA	ROW
Annual Gro	wth of G	DP								
1992-1995	- 1.6	- 1.6	2.1	- 11.6	2.6	1.3	1.8	1.9	7.3	2.4
1995-2000	3.5 <sup>a</sup>	$7.0^{\mathrm{a}}$	2.2	- 0.6	2.8	2.7	2.5	2.1	7.0	3.6
2000-2005	3.0 <sup>a</sup>	6.0 <sup>a</sup>	2.3	3.2	2.3	2.9	2.5	2.1	6.6	4.0
Annual pop	ulation gi	rowth <sup>b</sup>								
1992-1995	- 0.3	- 0.3	0.4	0.3	1.2	1.3	1.0	0.3	1.6	2.4
1995-2000	0.0	0.0	0.3	0.2	0.9	1.0	0.9	0.2	1.4	2.2
2000-2005	0.2	0.2	0.3	0.4	0.8	0.9	0.8	0.2	1.2	2.0
Annual capital accumulation										
1992-2005	3.0 <sup>a</sup>	3.0 <sup>a</sup>	3.0	2.0	3.2 <sup>a</sup>	3.4	3.4	4.8	7.2	2.9

Table 4.3:Macroeconomic forecasts between 1992 and 2005 (in percent)

<sup>a</sup> Own assumptions.

<sup>b</sup> Equal to growth rate of labor force.

Sources: GEHLHAR et al. (1994); USDA (1997b).

## Reform of the CAP and Implementation of the Uruguay Round

The policy options covering partial and complete liberalization of the CAP in connection with a uniform land subsidy in agriculture are implemented in the model as follows (Table 4.4). Under the partial liberalization scenarios, all direct payments for grains, non-grain crops and livestock that were introduced in the 1992 CAP reform are abolished. Border protection for non-grain crops, meat and milk products is reduced by 10 percent.<sup>8</sup> For wheat and other grains in the model, it is assumed for simplicity that, after completion of the 1992 reform, in 1996 there is no more border protection, although actually export subsidies and sometimes even export taxes were temporarily enforced.

As a substitute for current output subsidies a uniform payment on agricultural land is introduced which is not related to any specific product. Since the GTAP model works in percentage changes, any policy measure has to be translated into relative terms. The level of the land subsidy is determined by taking the amount of all current compensation payments and direct subsidies in the EU-15, i.e. 18.7 billion ECU in 1996, reducing it by 10 percent and dividing it by the total value of agricultural land as shown in the GTAP database for the EU-15.<sup>9</sup> Thus, a subsidy level is determined at about 75 percent

<sup>&</sup>lt;sup>8</sup> Partial liberalization of *ngc* and *met* is taken as an approximation for partial liberalization of sugar and beef which belong to these commodity aggregates.

<sup>&</sup>lt;sup>9</sup> Current expenditures on direct payments have been arbitrarily reduced by 10 percent, since some degree of budget reduction is very likely to occur in any further CAP reform.
of the factor price for land, which is equivalent to a payment of about 130 ECU per hectare of agricultural land. Technically, the ratio between the market price for land and the perceived factor price for producers is reduced such that factor costs per unit, net of the subsidy, are 25 percent of the actual market price.

	plib_s	plib_f	lib_s	lib_f	
Direct subsidies <sup>a</sup>					
wht, gro, ngc, olp	Abolishn product-rela	nent of all ted subsidies	Abolishment of all product-related		
met, mil, ofp			subsidies and taxes		
<b>Border protection</b> <sup>b</sup>					
ngc, met, mil	- 10 %	- 10 %	Abolish	ment of	
wht, gro, olp, ofp			border p	rotection	
Land subsidy <sup>c</sup>					
wht, gro, ngc, olp	75 %	75 %	75 %	75 %	
Growth in CEC-7	slow	fast	slow	fast	

Table 4.4:Model implementation of the scenarios

<sup>a</sup> Compensation payments, set-aside payments and animal payments from the 1992 CAP reform.

<sup>b</sup> Measured as the ratio domestic price/world market price; a reduction of border protection by 10 percent is equivalent to a reduction of the ratio by 10 percent.

<sup>c</sup> Direct factor payments, in percent of the relevant factor price.

Source: KIRSCHKE et al. (1997); own calculations.

When the land subsidy is transferred to the CEC-7 the question arises whether the same absolute amount per hectare should be paid or some adjustment to local price ratios should be made. An additional problem in the process of modeling a land subsidy is caused by the fact that information on land prices or land rents is hardly available in Central and Eastern Europe, since land markets are still not fully developed. In this paper, a land subsidy is introduced in CEC-7 which is equal to the EU-15 in *relative* terms, i.e. 75 percent of the local land rent, based on the value of land endowment in the GTAP database.<sup>10</sup> This seems to be a reasonable compromise in terms of a harmonized policy regime, since it would provide a uniform policy measure throughout the enlarged EU with some specific adjustment to regional conditions.

With respect to policy changes in non-agricultural sectors of the EU-15 and all sectors in the other model regions, it is assumed that the obligations from the GATT Uruguay Round are completely fulfilled until 2005. This part of the analysis was possible

<sup>&</sup>lt;sup>10</sup>Data on CEC-7 and the Former Soviet Union are generally quite poor even in the GTAP database (WAHL and YU 1997). This is especially true for primary factor endowments. However, the GTAP database seems to be the only source where this information is harmonized with other regions.

because version 3 of the GTAP database contains global protection data at pre- and post-Uruguay-Round rates (INGCO 1997). The command files for implementing the growth scenarios in the GEMPACK modeling software are provided in Appendix A-4.1.1.

## Modeling the Integration of the Central European Countries

EU integration of the CEC-7 is simulated in the model as a customs union. First, all barriers to trade within the CEC-7 region and between CEC-7 and EU-15 are removed. Second, with respect to trade with third countries border protection levels of EU-15 are applied to CEC-7. And finally, internal regulations under the CAP are transferred to the CEC-7. The milk quota which is still in operation under partial liberalization is applied in the new member countries by fixing output quantities at the actual level in 2005 prior to integration. New payments on land are applied at the same *relative* level as in the EU-15. The command files for implementing the integration scenarios in the modeling software are given in Appendix A-4.1.2.

Table 4.5 gives an impression of the levels of agricultural support in the EU-15 and the CEC-7 prior to enlargement.

	Ou	Output subsidies			port subsid	ies	Import tariff equivalents		
	EU-15	EU-15	CEC	EU-15	EU-15	CEC	EU-15	EU-15	CEC
	1996	2005	2005 <sup>c</sup>	1996	2005	2005 <sup>c</sup>	1996	2005	2005 <sup>c</sup>
wht	24.6	0.0	0.7	0.0	0.0	0.0	0.0	0.0	- 7.5
gro	16.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	11.8
ngc	71.0	0.0	0.4	30.4	17.4	0.0	50.0	35.0	11.2
olp	9.2	0.0	0.6	0.0	0.0	0.0	1.5	1.5	4.4
met	- 4.1	- 4.1	6.8	71.2	54.0	0.0	50.5	35.5	35.4
mil	- 0.2	- 0.2	0.2	91.3	72.2	0.0	126.6	105.7	- 2.1
ofp	- 10.8	- 10.8	1.2	0.6	0.6	0.0	12.7	12.7	18.9
mnfcs	- 0.8	- 0.8	- 0.2	- 0.1	- 0.1	- 1.4	8.5	4.2	8.1
svces	- 2.1	- 2.1	- 0.2	0.0	- 0.1	0.0	0.0	0.0	0.0
opp	- 12.8	- 12.8	- 3.5	0.4	0.2	0.0	0.6	0.6	1.5

Table 4.5:Protection levels in EU-15 and CEC-7 in 1996 and 2005<br/>(after partial liberalization of the CAP in EU-15; in percent)<sup>a,b</sup>

<sup>a</sup> Complete liberalization is omitted since all values are zero.

<sup>b</sup> Protection levels are given by the ratio [(domestic price - world price)/world price].

<sup>c</sup> Values for CEC-7 in 1996 are omitted since they only marginally differ from 2005.

Source: GTAP database, version 3; own calculations.

It shows protection levels in percent for the status quo in 1996 and the scenarios in 2005 after partial liberalization in the EU-15. Values for CEC-7 in 1996 are not given since they are assumed to remain basically the same until 2005. There are only marginal effects due to Uruguay Round obligations. Also, the values for EU-15 in 2005 after complete liberalization are omitted since in the agricultural and food sectors they are all equal to zero.

The potential effects of a partial liberalization in the EU-15 after 1996, i.e. abolishment of output subsidies in agriculture and reduction of border measures, as well as the need for adjustment for CEC-7 during the integration process become clear. This is especially relevant for export subsidies which are mostly zero in the transition countries prior to integration. As far as import tariffs are concerned there is serious upward pressure in non-grain crops and milk, whereas tariffs on meat are similar to EU-15. In feed grains, livestock, and other food products protection levels in CEC-7 are slightly higher than in EU-15.

### 4.4 Simulation Results

First, simulation results for the development period until 2005 will be briefly discussed, and then the EU enlargement effects will be looked at in more detail.

### Development Period until the Year 2005

For the EU-15 an overall GDP growth rate of about 31 percent has been forecast for the development period until 2005. Differences in output growth in the various sectors are mostly due to changes in agricultural policies (Table 4.6). Different growth rates in CEC-7 have only marginal effects for the EU-15.

With the exception of non-grain crops all sectors are growing due to overall expansion of the economy. Non-grain crops which include sugar and oilseeds suffer most from the abolishment of high output subsidies and border protection. Other food products (ofp) gain more from complete liberalization, since there is a certain level of taxation effective in the initial GTAP database which is also taken away in this scenario.

EU-15	wht	gro	ngc	olp	met	mil	ofp	mnfcs	svces	opp
plib_s	17.5	17.4	- 19.5	17.1	17.2	14.5	20.8	31.6	37.3	34.2
plib_f	17.4	16.7	- 19.9	16.6	16.8	14.3	20.7	31.5	37.3	34.1
lib_s	18.6	18.6	- 34.2	16.1	15.0	2.3	31.5	32.3	37.2	35.1
lib_f	18.5	17.8	- 34.6	15.6	14.6	1.9	31.5	32.2	37.3	35.0
CEC-7										
plib_s	26.8	26.4	38.9	29.9	28.0	30.4	27.2	40.4	44.5	34.4
plib_f	88.1	88.4	110.1	87.3	79.3	81.8	89.0	141.1	124.1	137.8
lib_s	29.0	26.7	44.0	35.8	37.7	62.9	23.4	38.7	44.3	32.9
lib_f	91.8	89.4	118.8	96.4	94.1	130.8	83.9	138.4	123.8	135.3

Table 4.6:Forecasts for output growth between 1995 and 2005 (in percent)

Source: Own calculations.

With respect to milk products is has to be explained why output is rising by about 14 percent under the partial liberalization scenarios, despite the fact that the quota system is assumed to be still in operation. This is a rather synthetic result due to the assumptions made in forecasting the development until 2005. GDP and population are growing at certain rates (Table 4.3) which causes a growth in private and intermediate demand. Instead of fixing domestic output rather the production quota is allowed to adjust in line with domestic demand.<sup>11</sup> The resulting growth in output is sensitive to the assumed growth rates of population and total factor productivity. The model result of 14 percent is certainly too high compared to EU forecasts which predict stagnating milk consumption for the period 1995-2005 (EU COMMISSION 1997b). But the predictions here are based on different assumptions, e.g. changes in consumer preferences over time have not been accounted for.

Manufacturing and service sectors are growing on average faster than agriculture and food industries. The limited endowment of land is not a constraint here. Moreover, these sectors are relatively capital-intensive and the fact that capital accumulation is assumed to be faster than the growth in labor force also accelerates output growth in these sectors.

The dominant effect on output in CEC-7 is the overall expansion in this region which is assumed to be 37 percent in the slow scenarios and 93 percent in the fast scenarios. In addition to domestic growth effects agricultural liberalization in the EU-15 especially affects non-grain crops, livestock, meat and milk products in the CEC-7. In these

<sup>&</sup>lt;sup>11</sup>This idea was taken from FRANDSEN et al. (1996).

sectors, output growth is significantly higher in the scenarios with complete liberalization of the CAP. Similar to the EU-15 output growth is strongest in manufacturing, primary products and services. Some of the output changes in the *fast* scenarios seem to be very high. As mentioned earlier they correspond to the assumption of an annual GDP growth between 6 and 7 percent which is certainly an upper bound.<sup>12</sup>

Changes in world market prices up to the date of enlargement are mainly caused by further CAP reform.<sup>13</sup> Table 4.7 shows the price effects simulated for the development period until the year 2005. Different growth rates in CEC-7 do hardly affect these results since they are a small region in the global economy.

Table 4.7:Changes in world market prices between 1995 and 2005 under<br/>various policy scenarios (in percent)

	wht	gro	ngc	olp	met	mil	ofp	mnfcs	svces	opp
plib_s	6.6	2.4	16.3	6.2	5.6	11.3	- 2.1	- 3.6	- 1.8	- 7.6
plib_f	6.1	2.0	15.8	5.8	5.2	11.0	- 2.3	- 3.6	- 1.8	- 7.7
lib_s	6.8	2.9	18.4	5.4	18.0	29.0	- 6.0	- 3.5	- 1.8	- 7.5
lib_f	6.3	2.5	17.9	4.9	17.6	28.5	- 6.1	- 3.6	- 1.8	- 7.6

Source: Own calculations.

Growth of GDP and population in other regions and implementation of the Uruguay Round also contribute to the price increase in agricultural and food products. In the nonagricultural sectors world market prices fall. These sectors benefit from reduced agricultural protection in the EU-15.

Figure 4.1 shows changes in the trade balance for the EU-15 until 2005 in the *slow* scenarios. Since the Armington specification in the model causes changes in exports as well as imports in each sector, the trade balance summarizes net effects on international trade. The trade balance for non-grain crops deteriorates heavily, between 35 and 58 billion 1992 ECU. Although not presented here, the quantity changes for most agricultural exports indicate that even under a partial liberalization the EU-15 might be able to fulfill its Uruguay Round obligations with respect to export quantities. This is with the exception of meat products for which export quantities are only reduced by

<sup>&</sup>lt;sup>12</sup>However, in the South East Asian economies output in some commodities doubled over the last ten years (see FAOSTAT database at the internet site http://faostat.fao.org/). Hence, some of the results in Table 4.6 might not be too unrealistic. As another example, production of oilseeds in the EU also heavily increased over the last decade (UHLMANN, 1996, p. 28).

<sup>&</sup>lt;sup>13</sup>The changes are comparable to the effects derived in HEROK and LOTZE (1997) for a CAP reform without any growth effects.

about 11 percent, while WTO commitments are about 30 percent (IATRC 1994). A further reduction in the level of border protection for meat products would be required. In the Agenda 2000, a 30 percent reduction in intervention prices has been proposed by the EU Commission.

Figure 4.1: Changes in trade balance in EU-15 until 2005 prior to enlargement (in Mill. 1992 ECU)



Note: The fast-growth scenarios are omitted since the results only differ marginally. Source: Own calculations.

Among the non-agricultural sectors of the EU-15, manufacturing and primary products lose world market shares which is due to strong expansion in Asia, including China, where an overall expansion of about 136 percent is projected. Only in the services sector the EU is able to improve the trade balance considerably. The total trade balance deteriorates which is in accordance with the assumed capital accumulation and the macroeconomic closure of the model.

### European Union Enlargement in the Year 2005

Production effects in the EU-15 as a consequence of an Eastern enlargement are relatively small. According to the GTAP database the share of CEC-7 in overall trade of EU-15 is about 4 percent and GDP in CEC-7 is about 3 percent of the GDP in EU-15. Hence, in this section model results are primarily discussed with respect to the new members. However, trade effects are also important for the EU-15, since they are mainly responsible for the resulting welfare changes.

The enlargement effects are primarily determined by the differences in protection levels between EU-15 and the new member countries as shown in Table 4.5. In the process of integration into the EU and implementation of CAP regulations, the new members completely remove all border protection measures towards the old EU countries. At the same time, border protection against imports from third countries is adjusted to levels prevailing in the EU-15 at the time of enlargement. Even after partial liberalization in the EU-15, import tariff equivalents for non-grain crops and milk products are still much higher, and there are no export subsidies at all in CEC-7 prior to the integration. For grains, livestock products, other food products, and manufactures border protection in the new member countries has to be decreased. Since some of the CEC-7 have reached their WTO tariff bindings already in 1996 (TANGERMANN 1997; TWESTEN 1998), EU integration under the partial liberalization scenarios discussed here might be problematic. However, the sectors in the GTAP model are large commodity aggregates whereas the WTO regulations apply to specific products, which makes it difficult to draw a conclusion from the model results in this respect. Moreover, the final conditions for the enlargement also very much depend on negotiations between the EU-15, the new members, and their WTO partners.

Figure 4.2 provides the changes in net trade in CEC-7 due to an EU integration under the slow growth scenarios. Non-grain crops and meat products gain a significant trade surplus in the case of partial liberalization of the CAP, whereas the balance for other food products deteriorates. Complete liberalization only improves the net trade position in manufactures while the total trade balance hardly changes at all.



Figure 4.2: Changes in trade balance in CEC-7 after EU integration in 2005 under the slow growth scenarios (in Mill. 1992 ECU)

Note: The fast growth scenarios are omitted; the trade effects have the same direction, but are generally stronger. Source: Own calculations.

Changes in bilateral trade flows (Table 4.8) give an impression of trade creation and trade diversion effects that can be expected from EU enlargement, e.g. a shift in trade from the Former Soviet Union in the East to the EU-15 in the West. Considerable trade creation occurs within the new EU-22 in all sectors, especially in scenario *plib\_s* imports in food products from EU-15 to CEC-7 increase heavily, by 114 percent. Furthermore, imports in non-agricultural sectors into CEC-7 are increased from all regions. On the other hand, agricultural and food imports from third countries into CEC-7 are reduced, e.g. by - 17 percent from FSU. The latter is clearly a trade diversion effect.

Under a completely liberalized CAP (*lib\_s*) mostly trade creation effects can be observed as more agriculture and food products are imported by the CEC-7 from all model regions. Imports in other sectors also increase, but at smaller rates.

plib_s	to $\rightarrow$				
	$\downarrow$ from	EU-15	CEC-7	FSU	ROW
Agriculture/Food	EU-15	- 2.8	113.6	0.2	- 0.1
Other sectors		- 0.7	18.5	0.5	- 0.2
Agriculture/Food	CEC-7	89.6	65.4	- 0.6	7.8
Other sectors		29.5	3.1	- 5.4	- 5.1
Agriculture/Food	FSU	- 2.3	- 17.1	- 2.5	- 0.3
Other sectors		- 0.9	8.1	0.8	- 0.9
Agriculture/Food	ROW	- 1.8	- 7.7	0.4	1.0
Other sectors		- 0.5	6.0	0.8	0.0
lib_s	to $\rightarrow$				
lib_s	to $\rightarrow$ $\downarrow$ from	EU- 15	CEC-7	FSU	ROW
lib_s Agriculture/Food	to $\rightarrow$ $\downarrow$ from EU-15	EU- 15 0.1	CEC- 7 47.6	FSU 0.3	ROW - 0.2
lib_s Agriculture/Food Other sectors	to $\rightarrow$ $\downarrow$ from EU-15	EU- 15 0.1 - 0.8	CEC- 7 47.6 16.8	FSU 0.3 0.3	ROW - 0.2 - 0.2
lib_s Agriculture/Food Other sectors Agriculture/Food	to $\rightarrow$ $\downarrow$ from EU-15 CEC-7	EU- 15 0.1 - 0.8 - 1.0	CEC- 7 47.6 16.8 47.4	FSU 0.3 0.3 2.1	ROW - 0.2 - 0.2 0.1
lib_s Agriculture/Food Other sectors Agriculture/Food Other sectors	to → ↓ from EU-15 CEC-7	EU- 15 0.1 - 0.8 - 1.0 35.0	CEC- 7 47.6 16.8 47.4 7.1	FSU 0.3 0.3 2.1 - 1.1	ROW - 0.2 - 0.2 0.1 - 1.2
lib_s Agriculture/Food Other sectors Agriculture/Food Other sectors Agriculture/Food	to → ↓ from EU-15 CEC-7 FSU	EU- 15 0.1 - 0.8 - 1.0 35.0 - 0.5	CEC- 7 47.6 16.8 47.4 7.1 14.5	FSU 0.3 0.3 2.1 - 1.1 - 0.2	ROW - 0.2 - 0.2 0.1 - 1.2 - 0.7
lib_s Agriculture/Food Other sectors Agriculture/Food Other sectors Agriculture/Food Other sectors	to → ↓ from EU-15 CEC-7 FSU	EU- 15 0.1 - 0.8 - 1.0 35.0 - 0.5 - 1.0	CEC- 7 47.6 16.8 47.4 7.1 14.5 7.4	FSU 0.3 0.3 2.1 - 1.1 - 0.2 0.5	ROW - 0.2 - 0.2 0.1 - 1.2 - 0.7 - 0.9
lib_s Agriculture/Food Other sectors Agriculture/Food Other sectors Agriculture/Food Other sectors Agriculture/Food	to → ↓ from EU-15 CEC-7 FSU ROW	EU- 15 0.1 - 0.8 - 1.0 35.0 - 0.5 - 1.0 0.2	CEC- 7 47.6 16.8 47.4 7.1 14.5 7.4 16.7	FSU 0.3 0.3 2.1 - 1.1 - 0.2 0.5 0.1	ROW - 0.2 - 0.2 0.1 - 1.2 - 0.7 - 0.9 - 0.6

Table 4.8:Changes in bilateral trade flows after EU enlargement in 2005 under<br/>the slow growth scenarios (in percent)

Source: Own calculations.

Table 4.9 shows the percentage changes in output for the CEC-7 as a consequence of EU integration in the year 2005. The relative changes do hardly differ between the scenarios with slow and fast growth. However, in terms of absolute changes there are differences between these scenarios since the enlargement occurs at different GDP levels.

Table 4.9:Changes in output in CEC-7 after EU integration in 2005<br/>(in percent)

	wht	gro	ngc	olp	met	mil	ofp	mnfcs	svces	opp
plib_s	- 2.3	- 5.6	15.6	2.2	11.4	0.0	- 14.9	1.7	- 0.7	- 7.0
plib_f	- 2.1	- 4.9	17.5	2.7	13.0	0.0	- 13.8	1.2	- 0.8	- 6.5
lib_s	- 1.7	- 3.0	- 1.9	- 2.1	- 5.9	0.8	- 7.4	4.3	- 0.6	- 3.9
lib_f	- 1.8	- 2.7	- 1.5	- 2.0	- 6.0	0.6	- 6.8	3.7	- 0.7	- 3.5

Source: Own calculations.

Under partial liberalization output strongly increases in non-grain crops and meat products due to higher protection levels. Milk production does not change since the quota level has been fixed at the pre-enlargement quantity. Production of other food products falls since border protection is reduced and more is imported from the old EU-15.

Complete liberalization implies broader reduction of government support in CEC-7 and lower output in agriculture and food. Production factors are moving into other sectors that were already less protected before the enlargement, e.g. manufactures, where they induce additional output growth. Under a completely liberalized agricultural policy there are no additional growth effects in CEC-7 due to EU integration.

Output changes in the model are essentially related to factor movements between sectors (Table 4.10). Under partial liberalization land shifts from grains and livestock production into non-grain crops. Labor moves into agricultural and food production. When the numbers in Table 4.10 are aggregated, overall labor force in agriculture and food is increased by 3.5 percent in scenario *plib\_s* whereas it is reduced by 0.5 in the rest of the economy. In the case of complete liberalization labor moves primarily into manufactures.

Land	wht	gro	ngc	olp	met	mil	ofp	mnfcs	svces	opp
plib_s	- 3.4	- 5.9	9.5	- 0.1	-	-	-	-	-	- 51.5
plib_f	- 3.0	- 5.1	11.1	0.5	-	-	-	-	-	- 51.0
lib_s	3.5	2.5	3.4	3.2	-	-	-	-	-	- 44.4
lib_f	4.2	3.5	4.4	4.0	-	-	-	-	-	- 43.7
Labor										
plib_s	- 1.7	- 5.5	19.5	3.6	10.9	- 0.4	- 15.2	1.3	- 1.1	- 3.1
plib_f	- 1.6	- 4.9	21.4	3.8	12.5	- 0.4	- 14.1	0.9	- 1.2	- 2.5
lib_s	- 4.7	- 6.1	- 4.9	- 5.1	- 5.8	0.9	- 7.3	4.4	- 0.5	- 0.1
lib_f	- 5.0	- 6.0	- 4.7	- 5.2	- 5.9	0.7	- 6.7	3.7	- 0.6	0.1

Table 4.10:Changes in demand for land and labor in CEC-7 after EU<br/>integration in 2005 (in percent)

Source: Own calculations.

Changes in output and trade in CEC-7 under the defined agricultural policy scenarios result in domestic price changes for output as well as factors of production (Table 4.11). Factor prices for labor and capital increase in all scenarios which is due to the general expansion effect after EU integration. In the case of land one has to distinguish between the market price and the perceived producer price which are differentiated by the land subsidy. Increased demand for land in agriculture in the model can only be met by the

relatively small primary products sector, i.e. supply of land is almost totally inelastic. Hence, the market price for land increases heavily in all scenarios. Because of a rising value marginal product for land and despite the land subsidy the producer price for land also rises by about 14 percent under a partially liberalized CAP. Under complete liberalization the producer price for land falls. Heavily increasing land prices indicate that a significant share of the subsidy is transferred to land owners. Since land is not yet fully privatized in most transition countries, it is not clear who would ultimately benefit from this policy.

	plib_s	plib_f	lib_s	lib_f
land (market price)	337.8	333.4	240.1	232.4
land (producer price)	14.1	14.3	- 12.2	- 13.4
labor	3.0	3.1	1.9	2.1
capital	2.2	2.4	2.1	2.3
wht	4.0	4.0	- 1.8	- 1.7
gro	3.0	3.1	- 2.3	- 2.1
ngc	7.5	7.5	- 2.4	- 2.3
olp	5.5	5.6	- 2.1	- 1.8
met	17.3	17.4	5.6	5.9
mil	62.9	64.6	- 0.7	- 0.5
ofp	19.1	19.4	0.9	1.2
mnfcs	1.1	1.3	0.1	0.4
svces	2.2	2.4	1.1	1.3
opp	4.9	5.1	3.4	3.6

Table 4.11:Changes in domestic output prices and factor prices in CEC-7 after<br/>EU integration in 2005 (in percent)

Source: Own calculations.

In the *plib* scenarios output prices for processed food increase significantly. The strong price increase for milk products of more than 60 percent is caused by the introduction of a quota restriction together with increased border protection. While producers clearly benefit from these changes, consumer welfare is negatively effected. This could be especially important in transition countries where the food share in household expenditure is currently still high. However, after significant economic growth in the pre-enlargement period expenditure shares might have adjusted downward to EU-15 levels. Under complete liberalization prices for most agricultural and food products, except for meat products, fall in CEC-7.

Finally, the resulting changes in welfare and budget expenditures will be discussed. Welfare changes for all model regions are given in Table 4.12 measured as the Equivalent Variation in million 1992 ECU.<sup>14</sup> The EU-15 benefits more from the enlargement after complete liberalization of the CAP, whereas the CEC-7 gain most after partial liberalization and fast growth. The other regions in the model, except the Former Soviet Union, lose in all scenarios which is mainly due to trade diversion effects of the EU integration. While EU-15 and CEC-7 abolish their internal trade barriers,<sup>15</sup> all other regions leave existing protection unchanged. Hence, they benefit less from rising output and trade in CEC-7. The overall global welfare increase is negligible. However, it has to be kept in mind that the numbers in Table 4.12 are the pure effects of EU enlargement. If welfare increases from the development period until 2005 are taken into account, the world as a whole is better off under a complete liberalization of the CAP.<sup>16</sup> In this case, EU enlargement occurs at a higher welfare level, therefore the additional welfare gain from the integration itself is smaller.

	plib_s	plib_f	lib_s	lib_f
EU-15	840	673	1 189	1 446
CEC-7	654	1 215	67	236
Australia/New Zealand	- 70	- 88	12	17
Canada	- 8	- 8	- 9	- 12
USA	- 148	- 190	- 142	- 202
Japan	- 204	- 275	- 321	- 469
Former Soviet Union	195	286	185	260
Asia	- 621	- 815	- 676	- 941
Rest of the World	- 395	- 535	- 157	- 243
World Total	243	263	147	91

Table 4.12:Welfare changes due to an EU enlargement in 2005 under various<br/>policy scenarios (Equivalent Variation in million 1992 ECU)

Source: Own calculations.

Nevertheless, the welfare gains calculated here are only part of the story. There is more to be expected than simply the static gains from trade. It can be concluded from other studies on regional integration (BALDWIN and VENABLES 1995; FRANCOIS 1997) that the

<sup>&</sup>lt;sup>14</sup>The Equivalent Variation is derived from the regional per-capital utility function in the GTAP model (HERTEL and TSIGAS 1997, p.35).

 <sup>&</sup>lt;sup>15</sup>Under a complete liberalization, of course, all external barriers in agriculture and food are also reduced.
 <sup>16</sup>HERTEL et al. (1997) calculate welfare gains from an EU Eastern enlargement that are much higher than the results in this paper. This is due to their assumption that in the course of EU integration productivity gains could be achieved in CEC-7. Here, a development period is modeled first with different rates of

new EU members will experience gains from economies of scale and increased competition as well as rising capital accumulation in the long run due to improved political stability. FRANCOIS (1997) concludes for an EU integration of the CEC-7 that the static trade effects are overwhelmed by the more dynamic effects in the longer run.

In order to provide a statement on the budgetary effects of EU enlargement, some side calculations have to be done since the standard version of the GTAP model does not single out budget expenditures and revenues. Besides, the absolute values of all subsidy equivalents in the GTAP database do not necessarily correspond to EU budget statistics, as the GTAP protection data also include "dirty" protection measures such as quantitative restrictions and non-tariff barriers.<sup>17</sup> Hence, only the relative changes in the value of protection from the model calculations are applied to the official data on the EU budget in 1996. The amount paid for land subsidies is calculated as 75 percent of the value of agricultural land for the EU-15 in 1996 and for CEC-7 in 2005. The results are shown in Table 4.13.

The sum of direct payments, export subsidies, import tariffs and factor subsidies for the EU-15 is reduced by about 18 percent after partial CAP liberalization and by 34 percent after complete liberalization. With respect to changes in other expenditures, e.g. guidance funds and accompanying measures, some additional assumptions have to made, especially in the case of complete liberalization. Even in these scenarios it seems unrealistic that expenditures on structural funds will be completely removed. The assumptions are partly taken from KIRSCHKE et al. (1997). Looking at the total budget, the savings under the various policy scenarios are even more pronounced.

In CEC-7 the introduction of a land subsidy together with changes in border protection after EU integration adds up to budget expenditures between 5.8 and 7.4 billion 1992 ECU. In the model, all subsidy payments within a region have to be paid by the regional household itself, with negative consequences for regional welfare.

<sup>&</sup>lt;sup>17</sup>BROCKMEIER et al. (1997) add the EU budget as a seperate entity to the model. Yet, another problem arises, as all non-tariff barriers are converted into tariff equivalents in the GTAP database (INGCO 1997). Taking the sum of all tariff equivalents in the EU-15 as a proxy for EU budget revenue yields a much higher value than actually reported in EU statistics.

EU-15	1996	plib_s	plib_f	lib_s	lib_f
Direct payments <sup>a</sup>	18 677				
Export subsidies	7 060	5 385	5 299		
Import tariffs	- 864	- 1 401	- 1 362		
Land subsidies		16 511	16 511	16 511	16 511
Subtotal	24 873	20 495	20 448	16 511	16 511
Other expenditures <sup>b</sup>	19 174	17 257	17 257	8 300 <sup>d</sup>	8 300 <sup>d</sup>
Other revenues <sup>c</sup>	- 1 287	- 644	- 644		
Total	42 760	37 108	37 061	24 811	24 811
CEC-7					
Output subsidies	104				
Export subsidies		853	1 180		
Import tariffs	- 768	- 591	- 660		
Land subsidies		5 837	6 884	5 837	6 884
Subtotal	- 665	6 098	7 404	5 837	6 884
Other expenditures <sup>b</sup>	n.a.	n.a.	n.a.	n.a.	n.a.
Other revenues <sup>c</sup>	n.a.	n.a.	n.a.	n.a.	n.a.
Total	- 665	6 098	7 404	5 837	6 884
Contribution to EU budget <sup>e</sup>		1 454	2 038	1 407	1 979
Net transfer from EU-15		4 645	5 366	4 4 3 0	4 906

Table 4.13:Budget effects of an EU enlargement in 2005 under various policy<br/>scenarios (in Mill. 1992 ECU)

<sup>a</sup> Compensation, set-aside and animal payments from the 1992 CAP reform.

<sup>b</sup> Market intervention, guidance funds, food aid refunds, accompanying measures; not available for CEC-7.

<sup>c</sup> Sugar levies; not available for CEC-7.

<sup>d</sup> Under complete liberalization "other expenditures" are defined as guidance funds and minimum intervention stocks.

<sup>e</sup> Calculated as 0.65 percent of regional GDP.

Source: KIRSCHKE et al. (1997); EU COMMISSION (1997c); own calculations.

However, it is most likely that the new members from CEC-7 will be net recipients in a new EU-22 for some time. Most of the support payments under the CAP will be paid out of the EU budget. The budget contribution of the new members can be calculated as 0.65 percent of GDP.<sup>18</sup> The bottom line in Table 4.13 provides the calculated transfer from the EU budget to CEC-7 net of their own contribution. It has to be considered, though, that these budget expenditures do not represent the total cost of enlargement from the EU perspective, since they only include direct protection measures. Structural aid and general support for CEC-7, which are already proposed in the Agenda 2000 (EU COMMISSION 1997a), will significantly increase EU budget expenditures during the

<sup>&</sup>lt;sup>18</sup>See FRANDSEN et al. (1996, p.15): total budget contribution of any member state is about 1.3 percent of GDP, while about half of the budget can be assigned to agriculture and food.

enlargement process. If the welfare increase from Table 4.12 and the direct budget transfers from EU-15 are added up, the total gain in CEC-7 from the enlargement in 2005 is between 1.7 percent ( $lib_f$ ) and 2.4 percent ( $plib_s$ ) of GDP at pre-enlargement levels.

## 4.5 Summary and Outlook

In this paper, the GTAP applied general equilibrium model is used for simulating the integration of seven Central European countries into the EU in the year 2005. The Common Agricultural Policy is modified by introducing a uniform subsidy on agricultural land which is currently discussed among other proposals. The land subsidy is transferred to the new members only in relative terms according to local price levels. Moreover, despite considerable uncertainty two different development paths until the year 2005 are simulated within the modeling framework.

Welfare gains from EU enlargement are mainly due to trade creation within a new EU-22. Under *partial liberalization* domestic prices in CEC-7 rise, labor and land are drawn into agricultural and food production and, hence, output and exports increase in these sectors. Domestic welfare in CEC-7 rises by about 2 percent of GDP at pre-enlargement levels. This includes budget transfers from EU-15 which amount to about 5 billion ECU. Despite these increased expenditures the total agricultural budget of the EU-15 does not rise due to savings as a result of agricultural policy reform. Not included in the budget expenditures are structural funds and general support measures since they are currently difficult to forecast. Due to trade diversion most other regions in the model lose after an EU enlargement.

Under *complete liberalization* of the CAP output in agriculture and food in CEC-7 declines after EU integration. Labor moves out of these sectors into manufactures, where output increases and the trade balance improves significantly. The overall welfare gain in CEC-7 from enlargement is slightly less than under partial liberalization, and in this case it is almost completely due to EU budget transfers related to the land subsidy. Nevertheless, expenditures under the CAP are heavily reduced which could provide room for more general structural aid for the new members. Although the direct welfare gains from EU integration are larger under a partially liberalized CAP, in the case of

complete liberalization the CEC-7 are able to grow faster prior to EU enlargement and the combined effects outweigh the partial liberalization results.

While interpreting the calculated effects of an EU enlargement one has to keep in mind that the model results crucially depend on the underlying assumptions with regard to agricultural policies, the general economic development up to the date of enlargement as well as indirect effects of the EU integration, like productivity shifts, investment incentives, and changes in the policy environment. Furthermore, endogenizing dynamic effects like inter-regional capital flows in the model would also change the results.

With regard to political viability it is quite clear, in view of the Agenda 2000, that a partial liberalization scenario seems to be a more realistic option in the near future. However, the proposed policy changes might not be "green box" compatible and they might not be appropriate for the CEC-7 to meet their WTO obligations. A uniform payment on agricultural land would be less market distorting than product-related compensation payments and it is likely to lower administrative expenses related to agricultural policies. This would probably improve the position of the EU in future WTO negotiations on agricultural and food products. However, new distortions on factor markets due to the land subsidy cannot be ruled out. Depending on the design of the payment, a considerable part of the subsidy might be transferred to land owners. This effect is questionable since a major policy objective of the CAP still is income support to active farmers.

There are certainly limits to the model in the current version. Changes in the CAP and effects of the EU enlargement are analyzed on a highly aggregated level. Consideration of product-specific aspects is only possible to a limited extent. Wider product disaggregation, especially in agriculture and food, would certainly be desirable.<sup>19</sup> As far as regional aggregation is concerned the group of CEC-7 does not consist of homogeneous countries. On the contrary, in many aspects they are very diverse which has to be neglected as long as the group is treated as a single region in the model. Data availability puts serious constraints to any empirical modeling exercise in transition economies. The GTAP database, although probably a collection of the best information

<sup>&</sup>lt;sup>19</sup>This could be an argument in favor of partial equilibrium modeling where single products are usually covered in more detail. However, version 4 of the GTAP database also provides more detail with respect to agricultural commodities and processed goods. More information is available from the GTAP internet site (see Footnote 4).

available, still has deficiencies regarding countries in Central and Eastern Europe and the Former Soviet Union. This should be kept in mind when the model results are interpreted.

One of the core assumptions of the current model are well-functioning markets in all sectors and regions. This is certainly not always the case in the CEC-7 and even less in the Former Soviet Union at this point. Possible extensions of the model include the implementation of monopolistic competition, imperfect factor markets and dynamics. There is plenty of scope for modeling the situation in transition countries more realistically in the future.

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#### Appendix A-4.1 GEMPACK Command Files for Policy Scenarios

This appendix lists the command files for implementing the policy scenarios discussed in Section 4.3 in the GEMPACK modeling software. In section A-4.1.1 the first file for the growth scenarios (*plib05s.cmf*) is completely provided. The details for the other growth scenarios are only provided where they differ from *plib05s.cmf*. In section A-4.1.2 the same applies to the EU integration scenarios. The first file (*plib\_s.cmf*) is complete, while the remaining files are only partly provided.

A-4.1.1 Command Files for Growth Scenarios until the Year 2005

```
plib05s.cmf
! This GEMPACK command file simulates growth until 2005, with partial
! liberalization of the CAP plus land subsidy, and slow growth in CEC-7
1
! Which model
1
auxiliary files = tp1010eu ;
! Solution method information.
1
method = euler ;
steps = 10 20 30;
1
! files
1
file gtapSETS = set3-03a.har;
file gtapPARM = par3-03.dat;
file gtapDATA = eu3int1.upd;
! The data file "eu3int1.upd" includes EU-12 enlargement to EU-15 and
! implementation of the 1992 CAP reform from previous simulations
! Next is necessary if reusing pivots is to succeed in multistep simulation !
iz1 = no i
!
Equations File = TP3-03 ;
        model = TP1010eu ;
        version = 1 ;
        Identifier = GTAPEU15.TAB with 10x10 data ;
!
! Simulation Specification Section
1
Verbal Description =
Model TP1010eu
Experiment "plib05s": Growth until 2005; partial CAP liberalization with
                    land subsidy 75 %; slow growth in CEC-7 (+21.17 %);
                    implementation of the Uruguay round
Solution Method: euler 10 20 30
1
! Closure rule
1
Exogenous pop
        psave
```

```
saveslack govslack incomeslack
          profitslack endwslack tradslack cgdslack
          ao af afe ava atr
          to tms txs tx tm tf
          qo(endw_comm, reg)
                               ;
Rest Endogenous ;
! Shocks for plib05s
! NOTE: "select from file xxx" in all cases means complete reduction from
! initial values
! Removal of set-aside requirements (These have been introduced before in
! the 1992 CAP reform) PLUS land subsidy
Shock qo("land", EU15) = uniform 5.26 ;
Shock tf("land", "wht", EU15) = uniform -79.17;
Shock tf("land", "gro", EU15) = uniform -79.17;
Shock tf("land", "ngc", EU15) = uniform -78.26;
Shock tf("land", "olp", EU15) = uniform -75;
! Cereals
Shock to("wht", EU15) = select from file toeu15a.shk ;
Shock to("gro", EU15) = select from file toeu15a.shk ;
! Oilseeds
Shock to("ngc", EU15) = select from file toeu15a.shk ;
! Sugar
Shock txs("ngc", EU15, NON_EU15) = uniform -10 ;
Shock tms("ngc", NON_EU15, EU15) = uniform -10 ;
! Beef
Shock txs("met", EU15, NON_EU15) = uniform -10 ;
Shock tms("met", NON_EU15, EU15) = uniform -10 ;
' Milk
Shock txs("mil", EU15, NON_EU15) = uniform -10 ;
Shock tms("mil", NON_EU15, EU15) = uniform -10 ;
! Animal premia
Shock to("olp", EU15) = select from file toeu15a.shk ;
! Uuruguay Round implementation (shocks taken from previous simulations)
! EU-15, Non-Agricultural sectors
Shock txs(NON_AG, EU15, NON_EU15) = select from file txs3ur.shk ;
Shock tms(NON_AG, NON_EU15, EU15) = select from file tms3ur.shk ;
! Non-EU-15, all tradable commodities
Shock txs(TRAD_COMM, NON_EU15, REG) = select from file txs3ur.shk;
Shock tms(TRAD_COMM, REG, NON_EU15) = select from file tms3ur.shk;
! Growth effects until 2005
1
! Country Order 1-5 AUZ CAN USA JPN E_U
                 6-10 EU3 CEA FSU ASIA ROW
1
1
! Population growth
Shock pop 1-5 = 12.35
                          13.81 11.91
                                          2.84
                                                  4.18;
Shock pop 6-10 = 4.18
                           0.60 4.07 18.87 31.66;
! Labor force growth
Shock qo 2 16 30 44 58 = 12.35 13.81 11.91
                                                      2.84
                                                              4.18;
                                              4.07 18.87 31.66;
Shock qo 72 86 100 114 128 =
                                4.18
                                       0.60
! Physical capital growth
Shock qo 3 17 31 45 59 =
                               50.6 54.1
                                                   54.1 83.0
                                                                   46.6;
Shock qo 73 87 101 115 129 =
                                 46.6
                                          46.9
                                                   29.4 146.9
                                                                   45.0;
1
```

```
! Total factor productivity growth (shocks taken from previous simulations)
Shock ava 1-10 = uniform
                               9.68;
Shock ava 12-21 = uniform 11.77 ;
Shock ava 23-32 = \text{uniform} 9.44;
Shock ava 34-43 = \text{uniform } -14.46;
Shock ava 45-54 = uniform 11.03 ;
Shock ava 56-65 = uniform 13.84 ;
! Next are the shocks for CEC-7
Shock ava 67-76 = \text{uniform } 21.17;
1
Shock ava 78-87 = uniform -30.32 ;
Shock ava 89-98 = uniform 80.72 ;
Shock ava 100-109 = uniform 24.18 ;
1
! Output File Specification (they are experiment dependent)
1
                         plib05s ;
Save Environment File
Solution
                  File = plib05s ;
                  File = plib05s.LOG ;
Log
!
! Updated data files
1
Updated file gtapSETS = set3-03a.upd;
Updated file gtapPARM = par3-03.upd;
Updated file gtapDATA = plib05s.upd;
!
Display file = tp3-03.dis ;
1
! Other Options
1
Extrapolation accuracy file = YES ;
CPU = yes ;
                             ____End of Command file.__
!
```

\_plib05f.cmf\_ 1 ! This GEMPACK command file simulates growth until 2005, with **partial** ! liberalization of the CAP plus land subsidy, and fast growth in CEC-7 ! 1 [...] ! Total factor productivity growth Shock ava 1-10 = uniform 9.68; Shock ava 12-21 = uniform 11.77 ; Shock ava 23-32 = uniform 9.44 ; Shock ava 34-43 = uniform -14.46 ; Shock ava 45-54 = uniform 11.03; Shock ava 56-65 = uniform 13.84 ; ! Next are the shocks for CEC-7 Shock ava 67-76 = uniform 93.05 ; Shock ava 78-87 = uniform -30.32; Shock ava 89-98 = uniform 80.72 ; Shock ava 100-109 = uniform 24.18 ; [...] End of Command file. !\_\_

!

!

! \_\_\_\_\_\_lib05s.cmf \_\_\_\_\_!
! This GEMPACK command file simulates growth until 2005, with complete
! liberalization of the CAP plus land subsidy, and slow growth in CEC-7
! \_\_\_\_\_!

[...]

1

! Shocks for lib05s
! NOTE: "select from file xxx" in all cases means complete reduction from
! initial values

! Complete liberalization in all EU-15 agriculture and food sectors
Shock to(AG\_FOOD, EU15) = select from file toeu15a.shk ;
Shock txs(AG\_FOOD, EU15, NON\_EU15) = select from file txseu15a.shk ;
Shock tms(AG\_FOOD, NON\_EU15, EU15) = select from file tmseu15a.shk ;

[...] !\_\_\_\_\_

\_\_\_\_\_End of Command file.\_\_\_\_\_

\_!

!

\_lib05f.cmf\_

```
! This GEMPACK command file simulates growth until 2005, with complete
! liberalization of the CAP plus land subsidy, and fast growth in CEC-7
!
```

[...]

1

1

```
! Shocks for lib05f
! NOTE: "select from file xxx" in all cases means complete reduction from
! initial values
! Complete liberalization in all EU-15 agriculture and food sectors
Shock to(AG_FOOD, EU15) = select from file toeu15a.shk ;
Shock txs(AG_FOOD, EU15, NON_EU15) = select from file txseu15a.shk ;
Shock tms(AG_FOOD, NON_EU15, EU15) = select from file tmseu15a.shk ;
! Total factor productivity growth
Shock ava 1-10 = uniform 9.68;
Shock ava 12-21 = uniform 11.77 ;
Shock ava 23-32 = \text{uniform} 9.44;
Shock ava 34-43 = \text{uniform } -14.46;
Shock ava 45-54 = uniform 11.03 ;
Shock ava 56-65 = uniform 13.84 ;
! Next are the shocks for CEC-7
Shock ava 67-76 = uniform 93.05;
!
Shock ava 78-87 = uniform -30.32 ;
Shock ava 89-98 = uniform 80.72 ;
Shock ava 100-109 = uniform 24.18 ;
!
[...]
                         ____End of Command file.__
!
```

#### A-4.1.2 Command files for EU integration scenarios

```
1
                            _plib_s.cmf
                                                                   _!
! This GEMPACK command file simulates integration of CEC-7 into EU-15
! in 2005 after partial CAP liberalization and slow growth in CEC-7
!_
                                                                    1
!
! Which model
1
auxiliary files = tp1010eu ;
1
! Solution method information.
1
method = euler ;
steps = 10 20 30;
1
! files
file gtapSETS = set3-03a.har;
file gtapPARM = par3-03.dat;
file gtapDATA = plib05s.upd;
! The data file is taken from previous simulation plib05s
1
! Next is necessary if reusing pivots is to succeed in multistep simulation !
iz1 = no ;
!
Equations File = TP3-03 ;
         model = TP1010eu ;
         version = 1 ;
         Identifier = GTAPEU15.TAB with 10x10 data ;
1
! Simulation Specification Section
Verbal Description =
Model TP1010eu
Experiment "plib_s": EU integration of CEC-7 in 2005, after partial
                    CAP liberalization and slow growth in CEC-7
Solution Method: euler 10 20 30
!
! Closure rule
! NOTE: the to-shocks are necessary for implementing the milk quota in CEC-7
Exogenous pop
         psave
         saveslack govslack incomeslack
         profitslack endwslack tradslack cgdslack
         ao af afe ava atr
         to(NSAV_COMM, "auz")
to(NSAV_COMM, "can")
         to(NSAV_COMM, "usa")
         to(NSAV_COMM, "jpn")
         to(NSAV_COMM, "fsu")
         to(NSAV_COMM, "asia")
         to(NSAV_COMM, "row")
         to(NON_AG, EU15)
         to(NON_AG, "cea")
         to(ENDW_COMM, EU15)
         to(ENDW_COMM, "cea")
         to(CGDS_COMM, EU15)
         to(CGDS_COMM, "cea")
         to("wht", EU15)
         to("gro", EU15)
         to("ngc", EU15)
         to("olp", EU15)
```

```
to("met", EU15)
          to("ofp", EU15)
          qo("mil", EU15)
          to("wht", "cea")
          to("gro", "cea")
          to("ngc", "cea")
          to("olp", "cea")
          to("met", "cea")
          to("ofp", "cea")
          qo("mil", "cea")
          tms txs tx tm tf
          qo(endw_comm,reg)
                             ;
Rest Endogenous ;
! Shocks for plib_s
! NOTE: The shocks which are used here for transferring EU-15 policies to
! CEC-7 have been previously derived and stored in files named xxx.shk
! Land subsidy
Shock tf("land", "wht", "cea") = select from file TFceats.SHK ;
Shock tf("land", "gro", "cea") = select from file TFceats.SHK ;
Shock tf("land", "ngc", "cea") = select from file TFceats.SHK ;
Shock tf("land", "olp", "cea") = select from file TFceats.SHK ;
! Direct commodity payments
Shock to("wht", "cea") = select from file TOceats.SHK ;
Shock to("gro", "cea") = select from file TOceats.SHK ;
Shock to("ngc", "cea") = select from file TOceats.SHK ;
Shock to("olp", "cea") = select from file TOceats.SHK ;
Shock to("met", "cea") = select from file TOceats.SHK ;
Shock to("ofp", "cea") = select from file TOceats.SHK ;
! Border protection measures
Shock tms(TRAD_COMM, NON_CEA, "cea") = select from file TMSceats.SHK ;
Shock tms(TRAD_COMM, "cea", "cea") = select from file TMS05ts.SHK ;
Shock tms(TRAD_COMM, "cea", "e_u") = select from file TMS05ts.SHK ;
Shock tms(TRAD_COMM, "cea", "eu3") = select from file TMS05ts.SHK ;
Shock txs(TRAD_COMM, "cea", NON_CEA) = select from file TXSceats.SHK ;
Shock txs(TRAD_COMM, "cea", "cea") = select from file TXS05ts.SHK ;
Shock txs(TRAD_COMM, "e_u", "cea") = select from file TXS05ts.SHK ;
Shock txs(TRAD_COMM, "eu3", "cea") = select from file TXS05ts.SHK ;
1
! Output File Specification (they are experiment dependent)
Save Environment File
                       plib_s ;
Solution
                 File = plib_s ;
                 File = plib_s.LOG ;
Loq
1
! Updated data files
Updated file gtapSETS = set3-03a.upd;
Updated file gtapPARM = par3-03.upd;
Updated file gtapDATA = plib_s.upd;
!
Display file = tp3-03.dis ;
1
! Other Options
1
Extrapolation accuracy file = YES ;
CPU = yes ;
                           ____End of Command file.___
```

NOTE: The command file for scenario *plib\_f* looks exactly like the one for *plib\_s*, except that data and shocks are taken from files derived in previous growth simulation *plib05f*.

```
_lib_s.cmf_
1
                                                                              !
! This GEMPACK command file simulates integration of CEC-7 into EU-15
! in 2005 after complete CAP liberalization and slow growth in CEC-7
                                                                                1
[...]
! files
!
file gtapSETS = set3-03a.har;
file gtapPARM = par3-03.dat;
file gtapDATA = lib05s.upd;
! The data file is taken from previous simulation lib05s
!
[...]
! Closure rule
1
Exogenous pop
          psave
           saveslack govslack incomeslack
          profitslack endwslack tradslack cgdslack
           ao af afe ava atr
           to tms txs tx tm tf
           qo(endw_comm,reg) ;
Rest Endogenous ;
! Shocks for plib_s
! NOTE: The shocks which are used here for transferring EU-15 policies to
! CEC-7 have been previously derived and stored in files named xxx.shk
! Land subsidy
Shock tf("land", "wht", "cea") = select from file TFceavs.SHK ;
Shock tf("land", "gro", "cea") = select from file TFceavs.SHK;
Shock tf("land", "gro", "cea") = select from file TFceavs.SHK;
Shock tf("land", "olp", "cea") = select from file TFceavs.SHK;
! Direct payments (if any)
Shock to(AG_FOOD, "cea") = select from file TOceavs.SHK ;
! Border protection measures (if any)
Shock tms(TRAD_COMM, NON_CEA, "cea") = select from file TMSceavs.SHK ;
Shock tms(TRAD_COMM, "cea", "cea") = select from file TMS05vs.SHK ;
Shock tms(TRAD_COMM, "cea", "e_u") = select from file TMS05vs.SHK ;
Shock tms(TRAD_COMM, "cea", "eu3") = select from file TMS05vs.SHK ;
Shock txs(TRAD_COMM, "cea", NON_CEA) = select from file TXSceavs.SHK ;
Shock txs(TRAD_COMM, "cea", "cea") = select from file TXS05vs.SHK ;
Shock txs(TRAD_COMM, "e_u", "cea") = select from file TXS05vs.SHK ;
Shock txs(TRAD_COMM, "eu3", "cea") = select from file TXS05vs.SHK ;
[...]
                           ____End of Command file.__
!
```

NOTE: The command file for scenario *lib\_f* looks exactly like the one for *lib\_s*, except that data and shocks are taken from files derived in previous growth simulation *lib05f*.

# 5 Foreign Direct Investment Impact in Transition Countries: A General Equilibrium Analysis Focusing on Agriculture and the Food Industry

## 5.1 Introduction

Over the last decade, Central and Eastern European countries (CEEC) have been undergoing a political and economic transformation at an unprecedented speed and intensity. Most economic sectors in these countries are suffering from a lack of capital and up-todate technology. This is especially true for the food industry which was generally one of the least efficient sectors in centrally-planned economies (OECD 1991). Foreign direct investment (FDI) is expected to contribute significantly to the process of economic restructuring in CEEC. Many politicians and economists in these countries believe that an inflow of foreign capital will accelerate economic growth, improve their trade balance, give access to modern technology and know-how and increase employment. The International Monetary Fund points out that "direct investment ... involves the transfer of a package of resources, including technological, managerial, and marketing expertise in addition to capital; these may have an even greater impact than the capital flows on a recipient country's production capabilities" (IMF 1985, p.1). Of course, these effects will not be realized to the same extent in all sectors of an economy. Some sectors are more attractive to foreign investors than others and there will be spillover effects between sectors, e.g. through intermediate input use.

Has FDI kept up with high expectations of CEEC policy-makers during the first years of transition? What are the general equilibrium effects of a capital inflow combined with technology transfer and spillovers? How is primary agriculture affected by foreign investment in food industries? These questions can only be answered in some kind of controlled experiment, since many overlapping factors are shaping overall economic performance, and the pure effects of FDI can usually not be isolated. In this paper, such an experiment is conducted with an applied general equilibrium (AGE) model developed by the Global Trade Analysis Project (HERTEL 1997). Data on FDI stocks in CEEC, collected by the United Nations Economic Commission for Europe (UNECE), are used to implement the relevant capital inflows into the transition economies. There are two model regions considered: the group of seven Central European countries

(CEC-7)<sup>1</sup> and the Former Soviet Union including the Baltics (FSU). Each of the model regions consists of ten sectors, with a focus on agriculture and food. The main objective of this paper is not only to model pure capital inflows, but to take into account the wider effects of technological and managerial know-how that are transferred in the process of FDI. Different options with respect to inter-sectoral labor mobility are also considered in order to take some market imperfections in transition countries into account.

The next section gives an overview of the theoretical effects of inward FDI on recipient economies. Section 5.3 provides some empirical facts on FDI in the CEEC. Then, four experiments are designed modeling pure and combined effects of FDI and technology transfer, and the model implementation in GTAP is given. In Section 5.5 simulation results are presented, followed by a concluding discussion.

## 5.2 Theoretical Effects of Foreign Direct Investment in Host Countries

There is a broad literature on determinants and implications of FDI in host countries.<sup>2,3</sup> Many studies have either dealt with capital flows between industrialized countries (e.g. FROOT 1993, SAFARIAN 1993) or with welfare consequences of foreign involvement in less developed countries (e.g. MORAN 1986; ANDERSSON 1991; RADKE 1992). The general attitude of country governments towards FDI has changed profoundly over the last decades from a very critical position in the 1970s to a more favorable point of view in the 1990s. The reasons are more faith in the workings of market systems, increasing globalization of economic activities, and a higher mobility of assets like technology, learning experience and managerial know-how. Governments have gained a much better appreciation of the costs and benefits related to FDI. Not only direct contributions of foreign affiliates are taken into consideration, but also the wider impacts on the host country's competitiveness and its dynamic comparative advantages (DUNNING 1994, p.4). In recent years the process of economic transition in Central and Eastern Europe has opened up new opportunities for FDI activities. Since the transition countries are a very heterogeneous group, experiences from industrialized as well as developing countries should be used for analyzing the effects of FDI in these emerging market

<sup>&</sup>lt;sup>1</sup> These are Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia.

<sup>&</sup>lt;sup>2</sup> General surveys are given by e.g. CAVES (1982), HELLEINER (1989), DUNNING (1994) and MEIER (1995).

<sup>&</sup>lt;sup>3</sup> "Host countries" are the locations where foreign investment actually occurs, while "home countries" are the countries of origin of foreign capital.

economies.<sup>4</sup> In general, positive as well as negative effects on host country welfare can be expected from FDI. The main findings in the literature will be summarized here.

# Factor endowment

The major direct effect of FDI in the host country is an increase in factor endowments through an inflow of capital, technology and advanced management know-how. These factors are especially scarce in newly developing market economies. FDI is likely to create additional output growth through rising productivity of local factors, e.g. labor and land, and falling production costs. Consequently, local consumers will benefit from lower product prices and better quality (MEIER 1995, p.248). However, after the start-up period of an investment, characterized by a net inflow of resources into the host country, any foreign investor will eventually expect to repatriate earned profits. Depending on the level of taxation this can cause a significant capital outflow and pressure on the host country's balance of payments (MEIER 1995, p.250-251).

While FDI is certainly not the most important source of foreign production capital in market economies, it might play a more important role in transition countries where capital markets are only slowly developing. Moreover, the transfer of intangible assets like technology and know-how between countries is often confined to FDI or licensing arrangements, because arms-length contracts tend to fail on these markets and firms try to explore internalization advantages (CAVES 1982, p.195-225; ETHIER 1994, p.120-123).

# **Externalities**

In addition to direct resource flows, the transfer of technology into host countries is also likely to have some external effects, as spillovers from foreign to local companies can be expected. "New technology is embodied in imported inputs and capital goods, sold directly through licensing agreements, or transmitted to exporters who learn about new techniques from their foreign buyers. In other cases, learning by doing among domestic firms, combined with investments in formal education and on-the-job training, is

<sup>&</sup>lt;sup>4</sup> ARTISIEN et al. (1993) provide an overview and some country studies on FDI in transition economies. WELFENS and JASINSKI (1994) analyze the role of FDI in the process of privatization.

critical" (HADDAD and HARRISON 1993, p.52).<sup>5</sup> Some authors argue that these positive externalities are the most important contribution of FDI to local economic development (MEIER 1995, p.249).

On the other hand, negative externalities related to FDI have been mentioned, especially in the context of developing countries. There might be cases where multinational firms shift pollution intensive production to less developed countries, or where foreign investors gain political power in the local administration (ANDERSSON 1991, p.29). Of course, these issues are hardly quantifiable.

# **Employment**

By setting up new plants and providing new production technologies, foreign investors may create local employment and thus generate additional labor income in host countries. This is especially important in CEEC after the collapse of formerly stateowned production facilities. New local private firms have not yet developed sufficient employment opportunities, and in many cases foreign investment is a precondition for starting production again. However, the overall employment effect of FDI depends on the choice of technology and whether foreign investment comes as a complement or substitute for local investments. If a foreign, capital-intensive production technology is substituted for local, labor-intensive production processes, overall employment might even decrease. (CAVES 1982, p.195-225; HELLEINER 1989, p.1469-1472). BATRA (1986) suggests that multinational corporations can cause a decline in total employment and real income of underdeveloped host countries, if their technology transfer is not accompanied by substantial capital investment. In this case foreign companies borrow from the local capital market and a crowding-out of local firms may occur. Hence, recipient countries should insist on maximum capital investment on the part of foreign investors.

## International trade and competitiveness

Increased production due to FDI will also affect a host country's trade balance. In many cases FDI is primarily undertaken in order to serve export markets by exploring

<sup>&</sup>lt;sup>5</sup> However, the same authors find that these effects are very difficult to quantify based on empirical observations. It is, for example, not clear whether FDI just causes a one-time rise in the level of local firms' productivity, or rather leads to a sustainable increase in the local rate of output growth.

locational advantages in the host country, like lower labor costs. Increased product quality and intra-firm linkages to the home country will increase a host country's competitiveness on international markets and might even provide access to new markets. Since foreign subsidiaries tend to import modern equipment from their home countries in the first expansion stage, FDI inflows typically cause an initial trade balance deficit in the host country. In the long run, however, rising output of subsidiaries will increasingly be exported, thus potentially turning around the balance-of-payments effect (RADKE 1992, p.34-35; WELFENS and JASINSKI 1994, p.233).

#### **Competition**

FDI will have an impact on a host country's market structure and competition. If local industries have an oligopolistic structure, foreign entrants will induce competitive pressure and improve the situation of local consumers as well as input suppliers. In the case where former state monopolies dominate the local market, as it frequently occurs in the food sector of many transition countries, FDI might be the only way to introduce market competition at all. On the other hand, foreign investors might be attracted just because there are oligopoly rents to be earned in a certain industry. In this case it would not be in their interest to increase local competition. In some transition countries foreign investors have entered the market so quickly that they by now dominate several industries.<sup>6</sup> Hence, it cannot be precluded that in some cases FDI *decreases* domestic competition which might suppress local entrepreneurship and make the host country more dependent on foreign companies (CAVES 1982, p.94-128; HELLEINER 1989, p.1458-1461; RADKE 1992, p.40-43).

# Government intervention and host country welfare

Finally, the impact of FDI on host country welfare depends on the type of government intervention and the level of taxation. In order to capture some of the benefits already mentioned, many governments try to attract foreign investors through tax concessions during the start-up period. They also regularly provide investment incentives in certain sectors in order to support their general development objectives.<sup>7</sup> If there are positive

<sup>&</sup>lt;sup>6</sup> This is true e.g. for food processing in Hungary (Table 5.2).

<sup>&</sup>lt;sup>7</sup> This might, on the other hand, also imply investment restrictions in other sectors which are declared "sensitive", e.g. the military industry.

externalities from FDI through technology spillovers, an investment subsidy by the host government might be justified (GEHRELS 1983; TSAI 1989).

However, while a foreign investor finally wants to repatriate earned profits, the host country government intends to extract a certain share of the surplus generated from an investment project. A host country's tax on foreign profits will also lead to a shift of capital and labor from foreign to local companies and thus increase local factor income (RADKE 1992, Chapter 6). The problem for the government is to determine an optimal level of taxation that does not deter companies from investing in the first place. The bargaining process between governments and foreign investors can be represented by a strategic game where taxes and investment levels are players' options, while profits and tax revenues are the pay-offs (ANDERSSON 1991, p.49-72; BRANDER and SPENCER 1987).<sup>8</sup>

Apart from direct profit taxation, other government interventions like trade policies will also alter the effects of FDI. Foreign investment in less developed as well as transition countries is often concentrated in technology-intensive industries where distorting trade policies are in place. If the entry into a certain sector is prohibited by import tariffs, FDI might be the only possibility to gain market access.<sup>9</sup> However, with import restrictions and high domestic prices there will be a trade-off for the host country between welfare losses from the policy intervention and gains from FDI. The overall welfare effect will be ambiguous and depending on the specific policy instrument in place.<sup>10</sup> Generally, in a partial equilibrium setting a pure capital inflow into a non-distorted sector is always beneficial to the host economy (MACDOUGALL 1960). In contrast, several studies using the Heckscher-Ohlin-Samuelson general equilibrium approach (e.g. BHAGWATI 1973; MARKUSEN and MELVIN 1979) derived the result that any small inflow of foreign capital into a tariff-protected, capital-intensive sector has a negative welfare impact, unless foreign profits are taxed. In a model with limited factor mobility and non-traded goods, TSAI (1987) shows that investment in the exportable sector is always beneficial to the host country. However, the welfare effect of FDI into a tariff-protected importable

<sup>&</sup>lt;sup>8</sup> Once FDI has actually occurred, foreign firms may still try to avoid taxation through "transfer pricing" activities. This means they buy intermediate inputs via intra-firm trade with internal prices calculated as to minimize the overall tax burden between home and host countries.

<sup>&</sup>lt;sup>9</sup> This is referred to as "tariff jumping investment" (ANDERSSON 1991, p.41).

<sup>&</sup>lt;sup>10</sup>See LOTZE (1997) for the case of the Polish sugar industry.

sector might be positive or negative, depending on model and parameter specifications (SECHZER 1988; ANAM and SUPAPOL 1992).

# 5.3 Recent Developments of Foreign Direct Investment Flows into Transition Economies

During the process of economic transition CEEC became a major scope for foreign capital, and the region is now playing an important role in global resource flows (SVETLICIC et al. 1993). It must be mentioned, though, that there are severe statistical problems in collecting reliable data on FDI in transition countries. Only slowly are these countries adopting the definition used by organizations like the IMF in which an FDI enterprise must have at least a ten percent foreign share in its capital (UNECE 1995, p.68). Practice varies within the region, and it is difficult to find unambiguous information. The UNECE collects statistical data from various national sources, i.e. national banks, balance-of-payments statistics, and investment agencies, with an industry disaggregration according to international standards in trade classification.

Figure 5.1 presents the recent development of cumulative FDI inflows into transition economies. In all countries FDI stocks have been rapidly increasing between 1992 and 1996. Detailed numbers for various countries are given in Appendix A-5.1.



Figure 5.1: Cumulative FDI inflows into CEEC (1992-1996)

Source: UNECE (1996)

Total FDI stocks in CEEC were at a level of 48 billion US\$ in July 1996, of which 73 percent have been invested in the CEC-7 and 27 percent in the FSU. The distribution of cumulative investment inflows among individual countries is very uneven. Hungary takes the biggest share with 29 percent of the whole region's FDI stock in 1996, followed by Poland, Russia and the Czech Republic (Table 5.1). Hungary also has one of the highest FDI per capita ratios, second only to Slovenia which experienced the highest annual per capita inflow in 1995. On a per-capita basis, the Czech Republic, Estonia and Poland are also among the more attractive investment locations. The least successful countries in acquiring FDI are the FSU, except the Baltics and Kazakhstan, as well as Bulgaria and Romania.

Country	Country Share in total FDI	FDI inflow in 1995	Cumulative FDI inflow 1992-1996	Ratio of FDI inflow to GDP	Ratio of FDI stock to GDP	Ratio of Gross Domestic Investment to GDP
	% in 1996	US\$ pe	er capita		% in 1995	
Belarus	0.7	4	32	0.2	1.5	25.0
Estonia	1.5	142	438	5.0	15.5	27.0
Latvia	1.0	78	194	3.4	8.4	21.0
Lithuania	0.8	30	95	1.6	7.0	19.0
Moldova	0.2	14	20	1.6	2.3	7.0
<b>Russian Federation</b>	13.7	17	40	0.8	1.5	25.0
Ukraine	2.3	8	17	0.5	0.9	25.0
Kazakhstan	6.8	53	168	4.0	12.6	22.0
FSU <sup>a</sup>	26.9	19	48	0.9	2.1	24.6
Bulgaria	1.3	13	62	1.0	4.9	21.0
Czech Republic	12.6	248	541	6.4	16.9	25.0
Hungary	28.9	373	1346	9.1	35.0	23.0
Poland	18.9	105	203	3.8	8.4	17.0
Romania	3.9	21	71	1.4	5.6	26.0
Slovakia	1.7	33	136	1.1	6.0	28.0
Slovenia	5.9	568	1387	6.9	19.7	22.0
CEC-7	73.1	126	337	4.6	14.2	21.4
CEEC (Average)	-	51	135	2.3	6.0	23.5
Argentina	-	113	772 <sup>b</sup>	1.4	8.1 <sup>c</sup>	18.0
United Kingdom	-	514	4172 <sup>b</sup>	2.9	20.9 <sup>c</sup>	16.0

 Table 5.1:
 Country distribution and per-capita FDI in various countries

<sup>a</sup> Not all of the newly independent states are listed due to missing data.

<sup>b</sup> Total FDI stock.

<sup>c</sup> Numbers for the year 1994.

Source: UNECE (1996); UNCTAD (1996); WORLD BANK (1997).
In terms of FDI inflows related to GDP, several transition countries have reached levels which are significantly above Western market economies. For matter of comparison in Table 5.1 numbers are also given for Argentina as a representative of the "upper middle income" group of countries (WORLD BANK 1997) and the United Kingdom (UK) as an industrialized country. When these figures are compared, however, it has to be taken into account that the level of GDP per capita in CEEC is still very low, on average about 2300 US\$ in 1995. Table 5.1 shows the highest ratio of annual FDI to GDP in 1995 at 9 percent for Hungary. Comparable figures for Argentina and the UK are 1.4 percent and 2.9 percent, respectively (UNCTAD 1996, p.64). In several CEEC, total FDI stocks in 1995 as compared to GDP were also higher than in Argentina. In Hungary, Slovenia, Czech Republic and Estonia, FDI stocks were even comparable to the UK. Moreover, in the most attractive locations, like Hungary and Slovenia, FDI inflows in 1995 were equivalent to about a third of annual gross domestic investment.

In Hungary, as the most popular location for foreign investors among the CEEC, FDI already in 1993 played an important role in the economy, which is especially apparent in the food industry (Table 5.2).

Table 5.2:The share of foreign companies in the Hungary economy<br/>(percentage shares in 1993)

	Food Industry	All Sectors
Employment	36.7	20.2
Sales	51.3	33.1
Exports	59.6	50.4

Source: UNECE (1994).

The share of foreign companies in overall employment, sales and exports in the food industry is higher than on average in the economy. There is a rising trend in these numbers, but the latest data available for the food industry are for 1993. While foreign companies in Hungary are significantly more trade-oriented than local competitors, their imports exceeded their exports and, hence, they have contributed to the foreign trade deficit in Hungary in recent years (UNECE 1996, p.31-32).

Figure 5.2 provides the sector distribution of cumulative FDI stocks in CEC-7 and FSU. Detailed percentage shares for individual countries are provided in Appendix A-5.1.



Figure 5.2: Sector distribution of FDI in transition countries (1996)

Source: UNECE (1996).

From UNECE statistics we can disaggregate five sectors that are suitable for the empirical simulations in this paper: agriculture, food processing, primary products<sup>11</sup>, manufactures, and services. Major FDI flows went into the service sector in both regions, i.e. 45 percent in CEC-7 and 40 percent in FSU. Food processing received about 12 percent of all FDI in CEC-7 and about 8 percent in FSU. A striking difference between the two regions occurs in primary products, which is due to the importance of FDI in the petroleum and gas industry in Kazakhstan. Agriculture received a negligible share of foreign capital in both regions.

## 5.4 Implementation of Foreign Direct Investment in the Modeling Framework

Empirical case studies on the role of FDI in transition economies have been mostly descriptive without using explicit economic models.<sup>12</sup> One way of determining the influence of FDI on host countries' economic development would be time series analysis (O'SULLIVAN 1993). However, foreign investment activities in CEEC have only started at the beginning of the 1990s and there are no sufficient time series available on FDI flows and major economic indicators. On the other hand, a multi-sector AGE

<sup>&</sup>lt;sup>11</sup>Primary products here include forestry, fishing, minerals, oil, coal, and gas.

<sup>&</sup>lt;sup>12</sup>See SVETLICIC et al. (1993) for an overview.

model provides an opportunity for simulation exercises and seems an appropriate tool for modeling the effects of foreign capital flows into transition economies.

The model applied in this paper was developed by the Global Trade Analysis Project (GTAP). The GTAP model is a standard applied general equilibrium model which is described in detail in HERTEL and TSIGAS (1997). It is written and solved using the GEMPACK modeling software (HARRISON and PEARSON 1996). A comprehensive database was collected from a variety of international sources and is described in McDoUGALL (1997). It consists of 30 regions and 37 sectors on a global level. Regions and sectors can be easily aggregated according to specific problem settings. However, with respect to transition economies the availability of national input-output tables and other relevant data is rather limited (WAHL and YU 1997). The GTAP database covers only two aggregate model regions in this area, the CEC-7 and the FSU. Moreover, the model economy consists of 10 sectors, each producing one output only:

- Agriculture: wheat, coarse grains, non-grain crops, primary livestock products
- Food processing: meat products, milk products, other food products
- Other sectors: manufactures, services, primary products (mining, energy, etc.).

In the standard model, regional endowments of primary factors of production, i.e. land, labor, and capital, are fixed. Capital and labor are only mobile between sectors and land as a so-called sluggish endowment is sector specific. MCDOUGALL and IANCHOVICHINA (1996) introduce international capital mobility into the GTAP model, but due to missing data on a global level they do not distinguish bilateral, sector-specific capital flows.

In order to model an exogenous inflow of FDI, the regions under consideration have to be isolated within the multi-region AGE framework. This can be done by fixing the relevant trade linkages and keeping prices and income constant in all other model regions. Then, the data on capital flows into CEEC described in the previous section are used for defining the relevant shocks to the model. Technically, the regional endowment of capital in CEC-7 and FSU is increased by the overall inflow of FDI, while specific use of capital in each sector is increased according to the distribution of FDI in both

regions.<sup>13</sup> It is assumed that the CEC-7 and the FSU are comparatively small economies and act as price takers on the international capital market.

In the model experiments, overall balance-of-payments changes are neglected. Normally, in a general equilibrium model one would expect that an exogenous inflow of capital into a country, ceteris paribus, would cause the balance of trade to deteriorate in order to keep external accounting balanced. However, in the present simulations the overall balance of trade for the model regions is held constant for several reasons. FDI, as already mentioned in Section 5.2, indirectly affects the balance of trade in both directions through additional exports on the one hand and imported inputs on the other. Moreover, in the case of transition countries significant capital *outflows* in recent years, due to political instability and uncertainty, have to be taken into account. It can be assumed that in some countries, e.g. the Russian Federation, the net balance of capital flows was even negative, i.e. more capital left the country than came in. Detailed data on FDI outflows from transition countries are hardly available and they are neglected here (UNECE 1996, p.5).

In addition to the pure increase in capital endowment, the model experiments should also capture employment effects of FDI as well as externalities arising from technology transfer. Since labor market imperfections and other rigidities to the adjustment process prevail in transition economies, two options are considered with respect to labor mobility. Although the model always generates full employment, the inter-sectoral movement of labor can be restricted. In the scenarios, labor is treated as being either perfectly mobile between sectors  $(M)^{14}$  or sluggish (*S*), which means that employment shifts between sectors are determined by a relatively small elasticity of transformation.<sup>15</sup> In the sluggish case wages differ across sectors, while under perfect labor mobility the wage rate will be equal throughout the economy.

Technology transfer is implemented in the model as an increase in total factor productivity (TFP) in those sectors which actually receive FDI. The options are either no change in TFP (O) or an increase in a certain proportion to the sector-specific FDI

<sup>&</sup>lt;sup>13</sup>Appendix A-5.2 provides the command files for implementing the scenarios in the GEMPACK modeling software.

<sup>&</sup>lt;sup>14</sup>This is the standard option in the GTAP model.

<sup>&</sup>lt;sup>15</sup>The elasticity of transformation for land and labor is set equal to -1 for all sectors. Moreover, the elasticities of substitution between primary factors have been reduced for the transition economies in all sectors by 50 percent compared to the standard parameters in the GTAP database.

inflow (T). In combining these options with regard to labor and technology, the following four modeling experiments can be defined (Table 5.3).

Technology transfer $\rightarrow$ $\downarrow$ Labor market	No increase in TFP <sup><math>a</math></sup> ( $O$ )	TFP <sup>a</sup> increase in proportion to capital inflow $(T)$
Perfect labor mobility between sectors ( <i>M</i> )	МО	МТ
Imperfect labor mobility between sectors (S)	SO	ST

Table 5.3:Description of FDI experiments

<sup>a</sup> TFP = Total factor productivity.

The GTAP model is formulated in percentage changes which requires that all exogenous shocks are also being defined in relative terms. In order to determine the increase in capital endowment in CEC-7 and FSU between 1992 and 1996, cumulative FDI inflows into each sector up to 1996 are divided by the value of capital endowment in 1992, the reference year of the GTAP database. FDI inflows into transition countries before 1992 were very small and they are neglected here. For simplicity FDI stocks in primary agriculture are set equal to zero, since on average they amount to less than 1 percent of local endowment in the database.<sup>16</sup> The UNECE is not providing any detailed information on FDI in the three food processing sectors of the model. Instead, additional information from the Polish Agency for Foreign Investment (PAIZ 1995) is used to split total FDI within the food industry into milk, meat and other processed products.

There is still another problem in determining the relevant FDI shocks for the model simulations. The exercises are conducted on a highly aggregated level. From the data it is not clear whether FDI primarily contributes to an increased supply of variable inputs, i.e. short-term liquid assets, or rather an increase in the overall value of fixed assets in the host country, i.e. total capital stock. Both cases are possible, but it seems more likely that FDI will mainly consist of fixed assets like buildings and large machinery. In this case, the ratio between the amount of inward FDI and local capital endowment and, hence, the shocks implemented in the simulations are relatively low. Table 5.4 provides the percentage increases in capital endowment implemented in the model sectors of CEC-7 and FSU. If, however, FDI became immediately fully effective as production capital, the relevant percentage increases in local capital were significantly higher. The

<sup>&</sup>lt;sup>16</sup>See Table A-5.1.2 in Appendix A-5.1.

corresponding shocks in this case are provided in Table 5.4 in brackets. These high shocks may represent an upper bound to the impact of FDI on the host economy, while the low shocks can be viewed as a more realistic scenario. The comparison of the low-shock and high-shock scenarios may serve as a kind of sensitivity analysis with respect to the overall impact of FDI in the simulations.

	CE	C-7	FSU		
	Capital	$\mathrm{TFP}^{\mathrm{a}}$	Capital	$\mathrm{TFP}^{\mathrm{a}}$	
Agriculture	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
Meat	4.5 (37.1)	0.5 (3.7)	1.4 (13.8)	0.1 (1.4)	
Milk	9.5 (79.3)	1.0 (7.9)	1.5 (15.7)	0.2 (1.6)	
Other food products	8.7 (72.3)	0.9 (7.2)	1.7 (17.3)	0.2 (1.7)	
Manufactures	9.6 (79.4)	1.0 (7.9)	1.0 (10.2)	0.1 (1.0)	
Services	4.7 (38.9)	0.5 (3.9)	0.4 (4.2)	0.04 (0.4)	
Primary products	0.6 (4.6)	0.1 (0.5)	1.8 (18.4)	0.2 (1.8)	
Total	5.8 (48.1)		0.7 (7.2)		

Table 5.4:Capital and TFP<sup>a</sup> shocks implemented in the model<br/>(percent increase; high-shock scenarios in brackets)

<sup>a</sup> TFP = Total factor productivity.

Source: Calculated from UNECE (1996) and the GTAP database (MCDOUGALL 1997).

As could be expected from the statistical data on FDI (Figure 5.1), the relative increases in capital are much higher in CEC-7 than in FSU. Cumulative inflows of FDI between 1992 and 1996 increase the value of the total capital stock by 5.8 percent in CEC-7 and 0.7 percent in FSU. If compared to the value of endowment capital, the share of all FDI inflows would be 48 percent in CEC-7 and 7.2 percent in FSU. The sector-specific relative increases reflect the distribution of FDI as illustrated in Figure 5.2.

Finally, the technology transfer effect has to be defined, i.e. the increases in total factor productivity caused by FDI. Generally, there is hardly any information available about the sector-specific technological gap between foreign and local production in transition countries. Neither is the time span known which would be necessary to fully implement advanced technologies in these economies. Hence, the following assumptions are made about the total technology transfer effect related to FDI. Any firm in the CEEC with some degree of foreign capital participation can on average realize a 10 percent increase in total factor productivity during the simulation period, i.e. between 1992 and 1996. Of course, in reality productivity might increase by much more depending on sector and

country specifics.<sup>17</sup> Although this estimate seems modest, it may be justified for the start-up phase of FDI projects in such a heterogeneous region like the CEEC. A 10 percent productivity increase for firms with foreign participation is then adjusted for the whole sector according to the foreign capital share. To give an example, if the share of FDI in capital endowment is 9.6 percent, as in manufactures in CEC-7, the total factor productivity for the sector as a whole is raised by 0.96 percent, and likewise for the other sectors.<sup>18</sup> Table 5.4 summarizes the changes in TFP for CEC-7 and FSU, with the high-shock scenarios provided in brackets.

## 5.5 Simulation Results

The objective of the AGE model application in this paper is to quantify some of the theoretical effects of FDI, as discussed in Section 5.2, in the context of the CEEC. The current version of the model provides results with respect to changes in total output in the various sectors as well as trade and employment effects in the model economies. Hence, it is possible to assess the overall expansion effect due to an increased capital endowment and the accompanying technology transfer. However, since the assumption of perfect competition is employed throughout, changes in the competitive situation on host country markets are not captured at this stage. Likewise, the interaction between FDI, local taxation and trade policy intervention has not been implemented in the present simulations. In the following paragraphs, only the results for the more realistic low-shock scenarios are discussed. The corresponding figures for the high-shock scenarios are provided in Appendix A-5.3.

The model results can be summarized by the changes in total GDP (Figure 5.3). In CEC-7, the pure capital transfer effect yields an expansion of total GDP by 1.8 percent for the time period under consideration. The results for labor being mobile or sluggish are very similar (MO, SO). This amounts to an annual growth rate of about 0.4 percent over 4 years. If technology transfer is taken into account, the cumulative expansion of GDP rises to about 3 percent over the simulation period, i.e. about 0.8 percent per year in scenario MT and 0.7 percent per year in scenario ST. The maximum expansion under the high-shock assumption would amount to 6.1 percent per year, or about 27 percent in

<sup>&</sup>lt;sup>17</sup>For example, overall productivity of the sugar sector in Western Europe is between 60 percent (United Kingdom) and 116 percent (France) higher than in Poland (F.O. LICHT 1989).

<sup>&</sup>lt;sup>18</sup>Since it is not explicitly distinguished between foreign and local firms in the model, spillovers between these groups cannot be considered.

total, in scenario MT.<sup>19</sup> If the low-shock scenarios are taken as the more realistic ones, it can be stated that the overall contribution of FDI to economic growth in CEC-7 was on average a little less than one percent per year up to 1996. The figures for the FSU are much smaller, and the various scenarios differ only slightly from each other. Scenario *ST* shows the highest growth rate at 0.9 percent in 4 years, i.e. about 0.2 percent per year.



Figure 5.3: Expansion of GDP due to FDI between 1992 and 1996 in the lowshock scenarios

Source: Own calculations.

Next, the structural changes within the model regions will be discussed. Table 5.5 shows that under the low-shock assumption output effects due to FDI are not very large in either of the two regions. In CEC-7 the strongest increase in all scenarios accrues to the manufacturing sector, followed by other food products, services and milk. With mobile labor the pure capital enhancement effect causes manufacturing output to grow by 3.4 percent (scenario MO). Food production rises between 1 and 2 percent, similar to services and primary products. Agriculture also gains from increased production in the other sectors, but only less than 1 percent. If technology transfer is considered according to the assumptions explained earlier (MT), there is, of course, an additional positive output effect in those sectors receiving FDI. However, in the model an increase in total

<sup>&</sup>lt;sup>19</sup>See Table A-5.3.1 in Appendix A-5.3.

factor productivity also has an input saving effect. Hence, in scenario *MT* those sectors with little or no FDI inflows experience a lower growth rate than under pure capital transfer. This result is dependent on the type of technology that is implemented. If the technical change were non-neutral, e.g. labor saving, spillover effects from food processing to agriculture were probably different. In the scenarios where labor is not perfectly mobile between sectors the output effects are slightly stronger in sectors with FDI inflows and weaker in sectors without FDI. This is due to the fact that the model always ensures full employment in the whole economy. An FDI inflow leads to a substitution of capital for labor, but if less labor can move out of the sector as compared to the mobile scenario, it will eventually be used in production and cause higher output. Of course, there are also changes in relative factor prices involved which will be discussed below. The results indicate that about two thirds of the total output change can be attributed to capital enhancement, while about one third is due to technology transfer effects.

		МО	MT	SO	ST
CEC-7	Wheat	0.9	0.6	0.7	0.5
	Coarse grains	0.9	0.6	0.7	0.5
	Non-grain crops	0.6	0.5	0.2	0.2
	Livestock	0.9	0.8	0.7	0.8
	Meat	0.9	1.4	1.0	1.5
	Milk	1.6	2.4	2.5	3.4
	Other food products	2.0	2.9	2.9	3.9
	Manufactures	3.4	4.7	3.8	4.3
	Services	1.9	2.4	1.8	2.7
	Primary products	0.8	0.5	0.2	0.2
FSU	Wheat	- 0.2	- 0.4	- 0.3	- 0.4
	Coarse grains	0.0	- 0.1	0.0	- 0.1
	Non-grain crops	0.2	0.2	0.2	0.2
	Livestock	0.2	0.2	0.3	0.3
	Meat	0.2	0.3	0.3	0.4
	Milk	0.2	0.3	0.4	0.5
	Other food producst	0.3	0.4	0.5	0.6
	Manufactures	0.2	0.2	0.2	0.3
	Services	0.2	0.3	0.2	0.3
	Primary products	1.0	1.1	1.2	1.4

Table 5.5:Changes in output due to FDI between 1992 and 1996 in the low-<br/>shock scenarios ( in percent)

Source: Own calculations.

Under the assumption that FDI capital becomes more directly effective in production, i.e. the high-shock scenarios shown in Appendix A-5.3, output rises as much as 38 percent for manufactures in scenario *MT*. This would be equivalent to an annual increase of about 8.5 percent over the four-year period of the simulation. These results seem to be unrealistically high, especially if compared to the real numbers, where output in many sectors in the transition economies did not grow but rather dropped between 1992 and 1996. It was mentioned earlier that the high-shock scenarios should be considered as an upper bound to the possible FDI impact.

Production effects in FSU as a consequence of FDI inflows are very low which could be expected from the FDI data discussed earlier. Here primary products like mining and energy stand out as the sector most strongly affected. But even if technology transfer and labor immobility is taken into account, the output effect only amounts to 1.4 percent in scenario *ST*. An interesting observation can be made in the FSU as compared to CEC-7. Grain production is negatively affected by FDI in the food industries. This can be explained by the fact that input substitution effects dominate the comparatively small expansion effect due to the capital inflow.

The output effects just discussed also cause changes in trade which are provided in Table 5.6. Two aspects are to be considered with respect to the trade effects. First, increased output due to FDI inflows causes exports to rise and imports to fall as locally produced goods are substituted for imported commodities. This improves a sector's trade balance. On the other hand, increased domestic production also leads to increasing imports of intermediate inputs from other sectors. This affects the trade balance in the other direction.

It becomes clear from Table 5.6 that sectors in CEC-7 which are more attractive to FDI, i.e. manufactures, milk, and other food products, experience an increase in exports between 4 and 7 percent in the scenarios with mobile labor, and between 5 and 13 percent in the scenarios with sluggish labor. Imports in milk and other food products fall which indicates that in these sectors local production of foreign investors is substituted for imported goods. On the other hand, imports in manufactures rise which indicates a rising demand for intermediate inputs. The trade balance for meat products deteriorates, even though domestic production is rising. Apparently, the intermediate input relationships are the dominating effect in this case.

		М	10	M	1T	S	0	S	Т
		Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
CEC-7	Wheat	- 3.4	3.2	- 6.1	4.6	- 7.4	5.7	- 9.1	6.7
	Coarse grains	- 3.0	3.0	- 5.5	4.2	- 6.7	5.2	- 8.3	6.1
	Non-grain crops	- 3.5	3.4	- 6.4	5.2	- 6.9	5.6	- 9.0	7.1
	Livestock	- 3.5	3.2	- 6.6	5.1	- 7.7	5.9	- 9.7	7.3
	Meat	- 0.4	1.6	- 1.4	2.7	- 0.3	1.7	- 0.4	2.3
	Milk	4.1	- 1.1	5.3	- 0.9	8.8	- 3.1	11.2	- 3.6
	Other food prod.	5.8	- 1.1	6.9	- 0.9	10.9	- 3.0	13.2	- 3.2
	Manufactures	4.3	1.2	6.6	1.1	5.0	1.1	5.7	1.3
	Services	0.2	2.0	- 1.2	3.3	- 0.7	2.5	0.8	2.1
	Primary products	- 4.2	4.9	- 7.1	6.4	- 7.1	6.3	- 8.4	7.1
FSU	Wheat	- 0.6	0.2	- 1.0	0.2	- 0.9	0.3	- 1.1	0.3
	Coarse grains	2.5	0.4	3.7	0.5	4.7	0.6	5.6	0.7
	Non-grain crops	- 0.3	0.3	- 0.6	0.3	- 1.0	0.6	- 1.2	0.6
	Livestock	0.1	0.5	0.1	0.7	- 0.1	0.9	0.0	1.0
	Meat	0.1	0.3	0.3	0.4	0.3	0.3	0.5	0.3
	Milk	0.0	0.2	0.1	0.3	0.3	0.2	0.5	0.1
	Other food prod.	0.4	0.1	0.8	0.1	1.3	- 0.2	1.8	- 0.4
	Manufactures	- 0.6	0.7	- 0.6	0.8	- 0.6	0.8	- 0.7	0.9
	Services	- 1.0	0.9	- 1.4	1.2	- 1.8	1.4	- 1.9	1.5
	Primary products	3.2	- 0.3	3.9	- 0.6	3.8	- 0.5	4.5	- 0.7

Table 5.6:Changes in exports and imports due to FDI between 1992 and 1996<br/>in the low-shock scenarios (in percent)

Source: Own calculations.

For all primary sectors in CEC-7 the trade balance also deteriorates. More of the local production in agriculture and other primary products is now used as an input in food industries, manufactures and services. However, the increased input demand by foreign firms is partly served through imports of agricultural and primary products which rise between 3 and 7 percent. The questions arises why an increased demand for raw products, e.g. in the food industry, is not completely served by local agricultural producers. Usually this is what most observers in transition countries would expect from FDI in food processing facilities. In the model, this result can be technically explained by the proportion between imported and domestic intermediate inputs which are not completely substitutable. Hence, a rising local demand for a product automatically causes imports to rise in a certain proportion. This seems not too unrealistic, given the fact that many local raw products in transition countries do not fulfil certain quality

standards. Especially, if a foreign investor produces for export markets, part of the intermediate inputs will probably have to be imported.

In the FSU the trade figures do not change much in any of the scenarios which corresponds to the small production changes reported in Table 5.5. Only in primary products, e.g. oil and gas, as well as coarse grains and other food products the trade balance slightly improves, with exports rising between 1.8 and almost 6 percent in scenario *ST*. These raw commodities traditionally have an important share in FSU exports.

Next, the effects of FDI on domestic factor prices will be discussed which are shown in Table 5.7.

		МО	МТ	SO	ST
CEC-7	Land	3.2	4.3	5.1	6.3
	Labor	1.3	2.8	3.0	4.1
	Capital	- 3.1	- 1.7	- 5.7	- 4.7
FSU	Land	0.6	0.8	1.5	1.7
	Labor	0.5	0.8	0.9	1.1
	Capital	- 0.1	0.1	- 0.3	- 0.1

Table 5.7:Changes in average factor prices due to FDI between 1992 and 1996in the low-shock scenarios (in percent)<sup>a</sup>

<sup>a</sup> Factor prices are weighted averages over all sectors.

Source: Own calculations.

Generally, due to FDI the price for capital in the host country tends to fall, while wages and land rents tend to rise. In CEC-7, an increased capital supply in food industries, manufactures and services causes overall rental rates to decline between about 2 and 6 percent. The decrease in the rental rate is smallest in scenario MT and strongest in scenario SO. When labor is sluggish, it is more difficult to substitute capital for labor and, hence, the price for capital falls more. Land rents in CEC-7 increase between 3 and 6 percent in the various low-shock scenarios. Technology transfer has an additional positive effect on value added of land in scenario MT, and a sluggish labor market also tends to increase land rents in scenarios SO and ST. The latter implies that more land and less labor is used in production, and since land is also a sluggish factor this drives up land rents. In the FSU, land rents change significantly only in the high-shock scenarios which are shown in the Appendix A-5.3.

Changes in average wages have to be seen in connection with sector-specific employment effects which will be discussed below (Table 5.8). Wages rise in CEC-7 on average between 1 and 3 percent in scenarios with mobile labor and between 3 and 4 percent with labor being sluggish. Again, the overall output growth in the economy tends to increase the marginal value product of labor and thus wages. This effect is even more pronounced with additional technology transfer (MT). When labor is imperfectly mobile, differences in wages occur between sectors with and without FDI inflows. In contrast to the average increases, which are shown in Table 5.7, sector-specific wages in the food industry do hardly change. In the FSU the effects are very small throughout the scenarios.

Changes in factor prices are partly determined by factor movements between sectors (Table 5.8).

		МО	МТ	SO	ST
CEC-7	Wheat	1.3	0.9	0.7	0.6
	Coarse grains	1.3	0.8	0.7	0.6
	Non-grain crops	0.9	0.8	0.2	0.3
	Livestock	1.3	1.1	0.8	0.9
	Meat	- 3.1	- 3.0	- 2.8	- 2.6
	Milk	- 6.1	- 6.5	- 4.0	- 4.1
	Other food products	- 4.3	- 4.3	- 2.4	- 2.2
	Manufactures	- 0.4	0.1	0.3	0.4
	Services	0.3	0.2	0.0	- 0.1
	Primary products	1.2	0.4	0.1	- 0.1
FSU	Wheat	- 0.3	- 0.6	- 0.3	- 0.4
	Coarse grains	- 0.1	- 0.2	- 0.1	- 0.1
	Non-grain crops	0.1	0.1	0.1	0.1
	Livestock	0.1	0.1	0.2	0.2
	Meat	- 0.9	- 1.0	- 0.7	- 0.8
	Milk	- 0.9	- 1.0	- 0.6	- 0.7
	Other food products	- 0.9	- 1.0	- 0.6	- 0.6
	Manufactures	- 0.2	- 0.4	- 0.2	- 0.2
	Services	0.1	0.2	0.1	0.1
	Primary products	- 0.3	- 0.5	0.2	0.1

Table 5.8:Changes in labor use due to FDI between 1992 and 1996 in the low-<br/>shock scenarios (in percent)

Source: Own calculations.

Here the focus is only on changes in labor use, because land is primarily used in agricultural production, and the changes in capital use are exogenously determined by the FDI inflows in the model simulations. In CEC-7, labor is partly substituted for by foreign capital in those sectors which receive a higher proportion of FDI. This effect is stronger in sectors which have a relatively small share in overall employment, e.g. the food industries. Small sectors can more easily adjust their employment without affecting average wages in the economy too much. In contrast, labor use in a relatively large sector, like manufactures, stays almost at the same level in all scenarios. In the high-shock scenarios, labor is heavily reduced only in the food industries.<sup>20</sup> Employment effects in the FSU are generally very small. Together, the changes in wages and sector-specific labor use in both regions imply that total labor income is reduced in the food industries, whereas it is increased in agriculture and other sectors of the economy.

The labor movement between food industries and primary agriculture in the model needs some special attention. About a third of the labor force moving out of food processing in CEC-7 is absorbed by the agricultural sectors. This is a theoretically consistent reaction, as agriculture does not receive any additional capital through FDI and tends to increase its factor demand on the labor market instead. However, in reality one would expect that employment in agriculture would continuously decrease over time and labor would only shift into other sectors of the economy, e.g. manufactures and services. Moreover, in the transition process many people remain unemployed, which is not possible in the model calculations. On the other hand, social security systems are not yet fully developed in most transition countries, and part of increased agricultural labor use in the present model experiments could probably be explained by subsistence production in rural areas. Moreover, many agricultural enterprises have set up their own processing plants in order to circumvent highly concentrated food industries. If the food industry as a whole became more competitive through FDI, small processing plants in rural areas would have to close down, while workers would go back into farming or become unemployed. Taking these effects into account is beyond the capabilities of the model at this point. A very rigid approach to modeling agricultural employment would be to just fix the amount of labor used in these sectors. This would force abundant labor from food industries into manufactures and services.

<sup>&</sup>lt;sup>20</sup>See Table A-5.3.3 in Appendix A-5.3.

In general, the differences in labor movements between the mobile and the sluggish scenarios are not as large as expected. Most of the adjustment is absorbed by sector-specific wage changes, and additional employment effects due to increased TFP are negligible. This indicates that imperfect labor market conditions, as they can be observed in transition countries, are not really reflected in the current model formulation and require a more elaborate approach. However, treating labor as a sluggish endowment at least provides a starting point for further extensions in modeling labor market rigidities and real unemployment.

## 5.6 Conclusions

In this paper, the economic impact of foreign direct investment in Central European countries (CEC-7) and the Former Soviet Union (FSU) is analyzed using the GTAP framework. Four experiments are designed for modeling pure and combined effects of capital and technology transfers. Imperfect labor mobility between sectors is also taken into account. The results crucially depend on assumptions about the nature of foreign capital that is transferred into transition economies. If FDI consisted mainly of short-term variable assets, as covered in the high-shock scenarios here, the immediate effects on economic growth would be much stronger than in the case where foreign capital would take the form of long-term fixed assets, like in the low-shock scenarios. The latter seems a more realistic assumption and, hence, the short-term impact of FDI on the host economies in the CEEC region is relatively modest.

The simulation period includes the years 1992 up to 1996. In the model, a cumulative expansion of GDP due to FDI is calculated between 2 and 3 percent in CEC-7, and less than 1 percent in FSU. This amounts to an average annual growth rate between 0.4 and 0.8 percent in CEC-7 and 0.2 percent in FSU. In the less likely case of the high-shock scenarios, the annual growth rate due to FDI goes up to 6.1 percent in CEC-7 and 2.1 percent in FSU. The model results also support the proposition that technology is weighing importantly in FDI activities. In connection with observed FDI flows even a technology transfer effect as modest as the one assumed here accounts for about half of the overall growth effects.

As far as domestic primary factor use is concerned, labor is moving out of sectors with relatively high FDI shares. Substitution effects due to cheaper capital are dominating the

expansion effect related to rising output. In the model, labor is moving out of the food industries into other sectors of the economy, including agriculture and other primary products. This results certainly over-simplifies the situation in transition economies, where rural unemployment is often a serious problem. But it also indicates that the transfer of capital intensive technologies might in the short-run rather aggravate the problem of local unemployment in the host countries. The implementation of labor market rigidities in the model does not change the results significantly. Although it somewhat reduces the quantity changes in factor use, most of the adjustment is absorbed by sector-specific wage changes.

Domestic agricultural production is gaining little from increased output in the processing industries. Improved technology in these sectors leads to more efficient use of raw products, and more intermediate agricultural inputs are being imported. However, over time there may be spillovers from the processing stage to primary agriculture, as foreign firms tend to provide training and advanced inputs to their raw product suppliers.

There are several possible directions for further research starting from this paper. First, the model results would certainly become more realistic, if the possibility of real unemployment could be implemented. Second, the nature of technology transfer and spillovers remain to be analyzed in more detail. Instead of a neutral change in TFP, e.g. labor-augmenting or intermediate-input-augmenting technical change could also be considered. Third, the influence of distorting trade policies on the welfare effects of FDI have been mentioned in theory, but so far not implemented in an AGE model. Likewise, the impact of foreign firms on local competition should be taken into account. Imperfect competition seems especially relevant to the agro-food sector in transition countries, where monopsonistic structures prevail in the processing industries.<sup>21</sup> Finally, more attention should be given to the significant capital *outflow* that occurred over the last years, especially in FSU, due to economic and political instability. This would be very difficult, however, since these transactions often take place on the black market and data are hardly available.

<sup>&</sup>lt;sup>21</sup>For an analysis of the interaction between FDI, trade policies, and imperfect competition in a partial equilibrium framework, see LOTZE (1997).

In reality, the potential positive effects related to FDI have been overshadowed by political and economic factors driving in the opposite direction. Until 1994 most CEEC still had negative rates of GDP growth (OECD 1996). Since then FDI has certainly contributed to the positive development which is reflected in the presented model results. However, the analysis in this paper also shows that the overall impact of FDI in the initial stages of the transformation process should not be overestimated. FDI should not be seen as a major source of finance, but rather as a basis for productivity growth and a nucleus in the transition economies which, in the long-run, might generate spillover effects that exceed the initial resource inflow.

## 5.7 References

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# Appendix A-5.1 Detailed Data on Foreign Direct Investment Flows into Transition Economies

Table A-5.1.1 in this appendix shows data on FDI stocks between 1992 and 1996 for individual transition countries. Table A-5.1.2 provides the sector distribution of FDI for individual transition countries and for the region as a whole in 1996.

	January 1992	January 1993	January 1994	January 1995	January 1996	July 1996
Belarus		7.7	263.6	286.8	331.0	347.5
Estonia		58.6	221.1	441.5	646.3	697.6
Latvia		33.4	74.6	294.3	485.3	496.1
Lithuania	34.4	74.0	191.6	241.9	351.6	375.2
Kazakhstan			1271.4	1910.1	2769.3	3244.0
Moldova			7.2	24.8	87.1	104.5
Russian Federation			2782.9	3364.9	5875.1	6550.2
Ukraine			219.4	483.5	890.6	1082.9
FSU <sup>a</sup> Total <sup>b</sup>	34.4	173.7	5031.8	7047.8	11436.3	12898.0
Bulgaria	14.1	64.8	191.9	412.4	517.4	609.9
Czech Republic	595.1	1598.3	2166.3	3028.7	5587.2	6045.2
Hungary	3137.0	5501.9	8342.0	9964.8	13740.2	13868.2
Poland	425.0	1370.0	2307.0	3789.0	7843.4	9045.4
Romania	225.8	516.2	651.9	1134.8	1597.2	1887.9
Slovakia		231.2	366.0	546.6	726.3	803.1
Slovenia			709.9	1629.0	2762.1	2806.2
CEC-7 <sup>c</sup> Total	4397.0	9282.4	14735.0	20505.3	32773.8	35065.9
CEEC <sup>d</sup> Total	4431.4	9456.1	19766.8	27553.1	44210.1	47963.9

 Table A-5.1.1:
 Cumulative FDI inflows into European transition economies by year (Mill. US\$)

<sup>a</sup> Former Soviet Union.

<sup>b</sup> Other countries in the region are omitted due to missing data.

<sup>c</sup> EU-Associates in Central Europe.

<sup>d</sup> All Central and East European transition countries. Source: UNECE (1996).

	Agriculture	Food	Primary products	Manufacture	Services	Total
CEEC (Mill. US\$)	350.0	5111.5	3564.9	18154.0	20783.5	47963.9
(Percent)	0.7	10.7	7.4	37.8	43.3	100.0
FSU (Mill. US\$)	102.9	1088.9	3307.5	3361.4	5037.2	12898.0
(Percent)						
FSU total	0.8	8.4	25.6	26.1	39.1	100.0
Belarus	2.8	3.3	0.0	58.9	35.0	100.0
Estonia	1.2	10.3	3.0	37.2	48.4	100.0
Latvia	0.1	10.3	2.1	12.6	75.0	100.0
Lithuania	2.1	17.5	4.5	29.0	47.0	100.0
Kazakhstan	0.0	4.1	74.6	19.8	1.5	100.0
Moldova	1.1	11.1	0.0	2.2	85.6	100.0
Russian Federation	0.7	9.0	12.8	26.1	51.4	100.0
Ukraine	2.5	14.5	0.0	34.1	48.9	100.0
CEC-7 (Mio. US\$)	247.1	4022.5	257.4	14792.6	15746.3	35065.9
(Percent)						
CEC-7 total	0.7	11.5	0.7	42.2	44.9	100.0
Bulgaria	0.0	0.0	0.0	34.6	65.4	100.0
Czech Republic	0.0	7.0	0.0	52.0	41.0	100.0
Hungary	1.2	12.1	0.8	34.3	51.6	100.0
Poland	0.3	16.4	0.3	48.5	34.4	100.0
Romania	2.5	15.1	5.3	33.8	43.3	100.0
Slovakia	0.2	2.1	1.1	41.4	55.3	100.0
Slovenia	0.0	4.8	0.0	47.4	47.7	100.0

 Table A-5.1.2:
 Sector distribution of FDI in transition economies (July 1996)

For explanations see also footnotes in Table A-5.1.1. Source: UNECE (1996).

#### Appendix A-5.2 GEMPACK Command Files for Scenarios

This appendix lists the command files for implementing the scenarios discussed in section 5.4 in the GEMPACK modeling software. The first file (*fdi\_mlo.cmf*) is completely provided, while the details for the other command files are only given where they differ from the first scenario.

```
_fdi_mlo.cmf
                                                                 !
!
! This GEMPACK command file simulates FDI in CEC-7 and FSU,
! with mobile labor, low FDI-shocks, and no technology transfer
!
                                                                 1
! Which model
1
auxiliary files = tp1010b ;
- 1
! Solution method information.
1
method = euler ;
steps = 10 20 30;
! files
1
file gtapSETS = set3-03.har;
file gtapPARM = par3-03.dat;
file gtapDATA = dat3-03.har;
! Next is necessary if reusing pivots is to succeed in multistep simulation !
iz1 = no;
Equations File = TP3-03 ;
        model = TP1010b ;
         version = 1 ;
         Identifier = GTAP94.TAB with 10x10 data ;
!
! Simulation Specification Section
1
Verbal Description =
Model TP1010b
Experiment "fdi_mlo": FDI in CEC-7 and FSU (food, manufactures, services)
Labor perfectly mobile, low FDI-shocks, no technology transfer, trade
balance fixed
 Solution Method: euler 10 20 30
! Closure rule
! This is a single-region general equilibrium closure
1
Exogenous pop
         saveslack govslack
         ao af afe ava atr
        qo(endw_comm,reg)
! swap incomeslack with y in "reg" except CEC-7 and FSU
        incomeslack("cea")
        incomeslack("fsu")
        y("auz")
        y("can")
        y("usa")
        y("jpn")
        y("e_u")
```

```
y("eu3")
         y("asia")
         y("row")
! swap profitslack with qo in "reg" except CEC-7 and FSU
         profitslack(prod_comm, "cea")
         profitslack(prod_comm, "fsu")
         qo(prod_comm, "auz")
         qo(prod_comm, "can")
         qo(prod_comm, "usa")
         qo(prod_comm, "jpn")
         qo(prod_comm, "e_u")
         qo(prod_comm, "eu3")
         qo(prod_comm, "asia")
         qo(prod_comm,"row")
! swap endwslack with pm in "reg" except CEC-7 and FSU
         endwslack(endw_comm, "cea")
         endwslack(endw_comm, "fsu")
         pm(endw_comm, "auz")
         pm(endw_comm,"can")
         pm(endw_comm,"usa")
         pm(endw_comm, "jpn")
         pm(endw_comm, "e_u")
         pm(endw_comm,"eu3")
         pm(endw_comm, "asia")
         pm(endw_comm,"row")
! swap tradslack with pm in "reg" except CEC-7 and FSU
         tradslack(trad_comm,"cea")
         tradslack(trad_comm, "fsu")
         pm(trad_comm,"auz")
         pm(trad_comm,"can")
         pm(trad_comm, "usa")
         pm(trad_comm, "jpn")
         pm(trad_comm,"e_u")
         pm(trad_comm,"eu3")
         pm(trad_comm,"asia")
         pm(trad_comm, "row")
! swap cgdslack with pm("cgds") in "reg" except CEC-7 and FSU;
! fix trade balance in CEC-7 and FSU
         DTBAL("cea")
         DTBAL("fsu")
         pm("cgds","auz")
         pm("cgds","can")
         pm("cgds","usa")
         pm("cgds","jpn")
pm("cgds","e_u")
         pm("cgds","eu3")
         pm("cgds","asia")
         pm("cgds","row")
! swap walraslack for psave
         walraslack
          to
1
! The following shocks are used to make sector-specific capital use exogenous
! in all sectors except primary agriculture
!swap qfe("capital",trad_comm,"cea") with tf("capital",trad_comm,"cea")
!swap qfe("capital",trad_comm,"fsu") with tf("capital",trad_comm,"fsu")
          tf("capital","wht","cea")
          tf("capital","gro","cea")
          tf("capital","ngc","cea")
          tf("capital","olp","cea")
          qfe("capital","opp","cea")
          qfe("capital","met","cea")
          qfe("capital","mil","cea")
          qfe("capital","ofp","cea")
          qfe("capital","svces","cea")
          qfe("capital","mnfcs","cea")
```

```
tf("capital","wht","fsu")
           tf("capital","gro","fsu")
           tf("capital","ngc","fsu")
           tf("capital","olp","fsu")
           qfe("capital","opp","fsu")
           qfe("capital", "met", "fsu")
           qfe("capital","mil","fsu")
           qfe("capital","ofp","fsu")
           qfe("capital","svces","fsu")
           qfe("capital","mnfcs","fsu")
!
           tf("capital","cgds","cea")
           tf("capital","cgds","fsu")
           tf("labor",prod_comm,reg)
           tf("land",prod_comm,reg)
           tf("capital",prod_comm,"auz")
           tf("capital",prod_comm,"can")
tf("capital",prod_comm,"usa")
           tf("capital",prod_comm,"jpn")
           tf("capital",prod_comm,"e_u")
           tf("capital",prod_comm,"eu3")
           tf("capital",prod_comm,"asia")
tf("capital",prod_comm,"row")
                                            ;
Rest Endogenous ;
! FDI shocks to endowment capital
! CEC-7
Shock qo("capital","cea") = 5.78;
Shock qfe("capital","opp","cea") = 0.55;
Shock qfe("capital","met","cea") = 4.47;
Shock qfe("capital","mil","cea") = 9.54;
Shock qfe("capital","ofp","cea") = 8.70;
Shock qfe("capital","svces","cea") = 4.68;
Shock qfe("capital", "mnfcs", "cea") = 9.55;
! FSU
Shock qo("capital","fsu") = 0.71;
Shock qfe("capital","opp","fsu") = 1.81;
Shock qfe("capital","met","fsu") = 1.35;
Shock qfe("capital","mil","fsu") = 1.54;
Shock qfe("capital","ofp","fsu") = 1.70;
Shock qfe("capital","svces","fsu") = 0.41;
Shock qfe("capital", "mnfcs", "fsu") = 1.00;
1
! Output File Specification (they are experiment dependent)
1
Save Environment File
                         fdi_mlo ;
                  File = fdi_mlo ;
Solution
                  File = fdi_mlo.LOG ;
Loq
!
! Updated data files
1
Updated file gtapSETS = set3-03.upd;
Updated file gtapPARM = par3-03.upd;
Updated file gtapDATA = fdi_mlo.upd;
1
Display file = tp3-03.dis ;
1
! Other Options
Extrapolation accuracy file = YES ;
CPU = yes ;
                             End of Command file.
1
```

!

\_\_fdi\_mho.cmf\_ ! ! ! This GEMPACK command file simulates FDI in CEC-7 and FSU, ! with mobile labor, high FDI-shocks, and no technology transfer ! ! [...] ! FDI shocks to endowment capital ! CEC-7 Shock qo("capital","cea") = 48.08; Shock qfe("capital","opp","cea") = 4.57; Shock qfe("capital","met","cea") = 37.13; Shock qfe("capital","mil","cea") = 79.32; Shock qfe("capital","ofp","cea") = 72.34; Shock qfe("capital","svces","cea") = 38.89; Shock qfe("capital","mnfcs","cea") = 79.39; ! FSU Shock qo("capital","fsu") = 7.22; Shock qfe("capital","opp","fsu") = 18.39; Shock qfe("capital","met","fsu") = 13.78; Shock qfe("capital", "mil", "fsu") = 15.69; Shock qfe("capital", "ofp", "fsu") = 17.29; Shock qfe("capital", "svces", "fsu") = 4.21; Shock qfe("capital", "mnfcs", "fsu") = 10.21; [...] \_\_\_\_\_End of Command file.\_\_\_\_\_ !\_\_\_

\_!

1

```
_fdi_mlt.cmf_
1
! This GEMPACK command file simulates FDI in CEC-7 and FSU,
! with mobile labor, low FDI-shocks, plus technology transfer
!
[...]
! FDI shocks to endowment capital
! CEC-7
Shock qo("capital","cea") = 5.78;
Shock qfe("capital","opp","cea") = 0.55;
Shock qfe("capital","met","cea") = 4.47;
Shock qfe("capital","mil","cea") = 9.54;
Shock qfe("capital","ofp","cea") = 8.70;
Shock qfe("capital","mnfcs","cea") = 9.55;
Shock qfe("capital","svces","cea") = 4.68;
! FSU
Shock go("capital", "fsu") = 0.71;
Shock qfe("capital","opp","fsu") = 1.81;
Shock qfe("capital","met","fsu") = 1.35;
Shock qfe("capital","mil","fsu") = 1.54;
Shock qfe("capital","ofp","fsu") = 1.70;
Shock qfe("capital", "mnfcs", "fsu") = 1.00;
Shock qfe("capital","svces","fsu") = 0.41;
! Technology transfer shocks
! CEC-7
Shock ao("opp", "cea") = 0.055;
Shock ao("met", "cea") = 0.447;
Shock ao("mil","cea") = 0.954;
Shock ao("ofp", "cea") = 0.870;
Shock ao("mnfcs", "cea") = 0.955;
Shock ao("svces", "cea") = 0.468;
! FSU
Shock ao("opp", "fsu") = 0.181;
Shock ao("met","fsu") = 0.135;
Shock ao("mil","fsu") = 0.154;
Shock ao("ofp","fsu") = 0.170;
Shock ao("mnfcs","fsu") = 0.100;
Shock ao("svces","fsu") = 0.041;
[...]
                       _____End of Command file.__
!_
```

```
_fdi_mht.cmf
1
! This GEMPACK command file simulates FDI in CEC-7 and FSU,
! with mobile labor, high FDI-shocks, plus technology transfer
!
[...]
! FDI shocks to endowment capital
! CEC-7
Shock qo("capital","cea") = 48.08;
Shock qfe("capital","opp","cea") = 4.57;
Shock qfe("capital", "met", "cea") = 37.13;
Shock qfe("capital", "mil", "cea") = 79.32;
Shock qfe("capital","ofp","cea") = 72.34;
Shock qfe("capital","mnfcs","cea") = 79.39;
Shock qfe("capital","svces","cea") = 38.89;
! FSU
Shock qo("capital","fsu") = 7.22;
Shock qfe("capital","opp","fsu") = 18.39;
Shock qfe("capital", "met", "fsu") = 13.78;
Shock qfe("capital","mil","fsu") = 15.69;
Shock qfe("capital","ofp","fsu") = 17.29;
Shock qfe("capital","mnfcs","fsu") = 10.21;
Shock qfe("capital","svces","fsu") = 4.21;
! Technology transfer shocks
! CEC-7
Shock ao("opp","cea") = 0.457;
Shock ao("met", "cea") = 3.713;
Shock ao("mil", "cea") = 7.932;
Shock ao("ofp","cea") = 7.234;
Shock ao("mnfcs", "cea") = 7.939;
Shock ao("svces","cea") = 3.889;
! FSU
Shock ao("opp","fsu") = 1.839;
Shock ao("met","fsu") = 1.378;
Shock ao("mil","fsu") = 1.569;
Shock ao("ofp", "fsu") = 1.729;
Shock ao("mnfcs","fsu") = 1.021;
Shock ao("svces","fsu") = 0.421;
[...]
                       _____End of Command file.___
!___
```

\_!

!

!

1

```
_fdi_slo.cmf_
1
! This GEMPACK command file simulates FDI in CEC-7 and FSU,
  with sluggish labor, low FDI-shocks, and no technology transfer
1
!
[...]
! files
file gtapSETS = set3-03s.har;
file gtapPARM = par3-03s.dat;
file gtapDATA = dat3-03.har;
! The set and parameter files now define labor as a sluggish endowment
! FDI shocks to endowment capital
! CEC-7
Shock qo("capital","cea") = 5.78;
Shock qfe("capital","opp","cea") = 0.55;
Shock qfe("capital","met","cea") = 4.47;
Shock qfe("capital","mil","cea") = 9.54;
Shock qfe("capital","ofp","cea") = 8.70;
Shock qfe("capital","svces","cea") = 4.68;
Shock qfe("capital", "mnfcs", "cea") = 9.55;
! FSU
Shock qo("capital","fsu") = 0.71;
Shock qfe("capital","opp","fsu") = 1.81;
Shock qfe("capital","met","fsu") = 1.35;
Shock qfe("capital","mil","fsu") = 1.54;
Shock qfe("capital","ofp","fsu") = 1.70;
Shock qfe("capital","svces","fsu") = 0.41;
Shock qfe("capital","mnfcs","fsu") = 1.00;
[...]
                         _____End of Command file.___
1
```

NOTE: The command files for the other scenarios with sluggish labor, i.e. *fdi\_slt*, *fdi\_sho*, and *fdi\_sht*, are exactly the same as for *fdi\_mlt*, *fdi\_mho*, and *fdi\_mht*, respectively, except that different set and parameter files are used, which define labor as a sluggish endowment.

## Appendix A-5.3 Selected Model Results for the High-shock Scenarios

		МО	MT	SO	ST
CEC-7	Wheat	6.6	3.8	3.9	2.7
	Coarse grains	6.4	4.0	4.1	3.2
	Non-grain crops	4.2	3.7	1.1	1.4
	Livestock	6.3	6.2	4.3	5.0
	Meat	6.1	10.4	5.2	9.9
	Milk	10.3	17.0	11.4	19.6
	Other food products	13.6	22.3	15.9	26.2
	Manufactures	25.3	38.0	24.3	30.3
	Services	14.8	18.8	12.9	21.3
	Primary products	5.9	2.9	1.8	1.4
	Value of total GDP	12.7	26.9	11.5	21.4
FSU	Wheat	- 2.0	- 4.4	- 2.8	- 3.8
	Coarse grains	- 0.3	- 1.3	- 1.0	- 1.6
	Non-grain crops	1.2	1.1	0.8	0.9
	Livestock	1.8	1.8	2.3	2.4
	Meat	1.7	2.9	2.3	3.6
	Milk	2.0	3.1	3.1	4.4
	Other food products	2.9	4.3	4.4	5.9
	Manufactures	2.0	2.3	2.4	2.7
	Services	2.2	2.9	1.8	2.9
	Primary products	9.8	11.4	11.4	13.4
	Value of total GDP	5.3	7.8	6.8	8.8

# Table A-5.3.1:Changes in output and total GDP due to FDI between 1992 and<br/>1996 in the high-shock scenarios (in percent)

Source: Own calculations.

		МО	MT	SO	ST
CEC-7	Land	23.2	35.5	32.8	46.3
	Labor	8.9	23.2	19.7	30.6
	Capital	- 18.4	- 8.1	- 32.0	- 26.3
FSU	Land	5.5	7.6	13.0	15.3
	Labor	4.9	7.5	8.3	10.4
	Capital	- 1.3	1.1	- 3.0	- 1.1

Table A-5.3.2:Changes in average factor prices due to FDI between 1992 and<br/>1996 in the high-shock scenarios (in percent)

Source: Own calculations.

Table A-5.3.3:	Changes in labor use due to FDI between 1992 and 1996 in the
	high-shock scenarios (in percent)

		МО	MT	SO	ST
CEC-7	Wheat	9.0	5.1	3.8	2.7
	Coarse grains	8.8	5.4	4.0	3.2
	Non-grain crops	6.2	5.0	1.0	1.5
	Livestock	8.6	7.9	4.2	5.0
	Meat	- 21.8	- 21.2	- 18.0	- 17.0
	Milk	- 35.6	- 38.0	- 22.3	- 22.9
	Other food products	- 26.8	- 26.3	- 14.6	- 12.4
	Manufactures	- 2.1	1.4	1.7	3.1
	Services	1.4	0.7	0.1	- 0.6
	Primary products	8.1	1.4	0.1	- 1.2
FSU	Wheat	- 2.8	- 5.6	- 3.0	- 4.0
	Coarse grains	- 1.0	- 2.2	- 1.3	- 1.8
	Non-grain crops	0.6	0.5	0.5	0.6
	Livestock	1.4	1.3	1.9	2.0
	Meat	- 8.9	- 9.3	- 7.0	- 7.2
	Milk	- 8.4	- 9.2	- 5.7	- 6.2
	Other food products	- 8.6	- 9.3	- 5.2	- 5.6
	Manufactures	- 2.2	- 3.3	- 1.5	- 1.7
	Services	1.0	1.4	0.5	0.6
	Primary products	- 3.3	- 4.4	1.4	1.2

Source: Own calculations.

# 6 Foreign Direct Investment in the Polish Sugar Industry: Do Trade Policies and Imperfect Competition Matter?

## 6.1 Introduction

Food processing was generally one of the least competitive industrial activities in centrally-planned economies (OECD 1991). It was characterized by permanent underinvestment compared to primary agriculture and other industrial sectors. Even now, after several years of transition in the Central and East European countries (CEEC), restructuring of the food processing sector has been particularly slow and many industries are still controlled by the state. This is even more serious as the processing stage often acts as a bottleneck to agricultural production. The downstream linkages are crucial in the process of developing an efficient agriculture and food sector (WALKENHORST 1997, p.1).

Foreign direct investment (FDI) is expected to contribute significantly to the improvement of agriculture and food sector performance during the transition from centrally planned to market economies. Capital and modern technology are especially scarce factors in CEEC, and policy-makers are trying to create favorable conditions in order to capture some of the positive welfare effects from FDI. Primary impacts include output expansion and increased local employment due to foreign capital inflow and new access to foreign markets. Secondary benefits are related to technology transfer from foreign to local firms as well as improved competition on domestic markets.<sup>1</sup> However, from a recipient country's perspective there might also arise some costs from foreign activities. First, after an initial set-up phase of a project, eventually any foreign investor wants to make profits and repatriate at least part of them back to the home country. The local government might try to capture some of these profits through taxation, but there are limits to the tax level, as high taxes will deter foreign investors entirely from entering the country. Second, if there are trade policies in place which protect local industries from foreign competition, the rents that are created by these policies will also accrue to foreign entrants. Under certain conditions foreign firms might only be attracted by the rents and not necessarily by other favorable production conditions like low labor costs or domestic market size.

<sup>&</sup>lt;sup>1</sup> For a general discussion of the effects of FDI see CAVES (1982).

The net welfare effects of FDI very much depend on the interaction between the level of investment, profit taxation, trade policy distortions and local competition. In this paper, the Polish sugar industry is taken as a case study for analyzing these interactions in an empirical model. In the next section, the current situation in the Polish sugar industry is described. Section 6.3 provides the theoretical background for the empirical model implemented in Section 6.4. The policy scenarios and some model results are presented in Section 6.5 which is followed by some concluding remarks.

## 6.2 The Polish Sugar Industry

Poland has a high potential for sugar production and exports and still belongs to the biggest sugar producing countries in Europe (BARTENS and MOSOLFF 1996). Table 6.1 shows the overall development of sugar production and consumption in recent years.

		1992	1993	1994	1995	1996
Area harvested	1000 ha	374	374	399	396	378
Total production	1000 t	1 865	1 567	2 170	1 492	1 714
Total consumption	1000 t	1 623	1 600	1 600	1 652	1 762
Export	1000 t	221	87	313	65	4
Import	1000 t	25	48	16	166	59

 Table 6.1:
 Sugar production and consumption in Poland in recent years<sup>a</sup>

<sup>a</sup> Sugar quantities measured in raw sugar value (RSV); total sugar balances are not zero due to statistical errors.

Source: BARTENS and MOSOLFF (1996; 1998).

The total area of sugar beets has been relatively stable over recent years at a little less than 400 000 ha. Total sugar production has been between 1.5 and 2.2 million tons of raw sugar value (RSV).<sup>2</sup> Sugar consumption is estimated between 1.6 and 1.8 million tons which gives Poland some potential for sugar exports in average years. If productivity could be increased to Western European standards, Poland would certainly become a major sugar exporter. This is even more likely, as current sugar consumption per capita in Poland is still about 14 percent above the European Union (EU) average, and this might fall over the next years (BARTENS and MOSOLFF 1998).

<sup>&</sup>lt;sup>2</sup> "Raw sugar value" is a uniform quantity measure for various types of processed sugar products, like raw sugar, white sugar, or molasses.

Due to low labor costs and favorable agro-climatic conditions, sugar beet farming in Poland is very competitive by international standards. However, the situation in the processing stage is quite different. The average plant size of sugar factories is small, production costs are high and overall productivity in the sector is low compared to Western European standards (WALKENHORST 1997, p.4). Pure processing costs are estimated about 25 percent higher than EU average, not to mention the most efficient processing plants in sugar surplus regions in France and Germany (SOMMER 1998, p.37).

Table 6.2 compares several indicators on productivity and input use for the sugar industries in Poland and Germany.

		Poland	Germany
Sugar beet yield (1993-95)	t beet / ha	30.5	50.4
Sugar yield (1993-95)	t RSV <sup>a</sup> / ha	4.4	8.4
Number of factories		76	38
Average factory capacity	t beet / day	2 255	7 730
Sugar extraction rate	percent	80.4	86.9
Input use:			
Energy consumption	kg coal / t beet	52.1	20.0
Limestone consumption	kg / t beet	50.9	33.0
Coke consumption	kg / t beet	4.4	2.6

Table 6.2:Key indicators for sugar processing in Poland and Germany<br/>(1994/95)

<sup>a</sup> RSV = raw sugar value

Source: LOMZA (1996); WALKENHORST (1997).

Sugar beet yields are about 65 percent higher in Germany, while total production of sugar, measured in RSV per hectare, is even 90 percent higher. Low productivity in the processing stage in Poland is partly due to small plant sizes and a low level of automation (LOMZA 1996). Currently there are 76 sugar factories in operation in Poland with an average potential of 2 255 tons of sugar beet per day. The average German sugar plant processes more than three times this amount per day. The use of energy and material input like limestone and coke in Poland is between 54 and 160 percent higher than in Germany. Moreover, the average Polish sugar plant employs about three times as many people as a comparable Western factory (WALKENHORST 1997, p.11).

Like in the EU, the sugar sector in Poland is characterized by strong government intervention. As Poland belongs to the first five CEEC candidates for EU integration, domestic policy measures will have to be harmonized with EU regulations over the next few years. In 1994, the Polish Sugar Act established a sugar regime very similar to the EU system. A production quota (A) as well as an export quota (B) were distributed among processors. The A-quota was fixed at about 1.5 million tons of sugar. The minimum domestic price for sugar was set about 60 to 70 percent above world market prices, but still below Western European intervention prices (EUROPEAN COMMISSION 1995; OECD 1996; WALKENHORST 1997).

In contrast to other industries in Poland, the privatization process in the food processing sector in general has been very slow. This is especially true for the sugar industry, where state involvement is still high, decision-making is centralized, and hence competitive pressure is low (LOMZA 1996). It can be assumed that raw input suppliers, like sugar beet farmers, receive significantly lower prices for their products than in a competitive market environment. In order to improve the situation, the privatization ministry created 4 sugar holdings that should be privatized in the near future. Western sugar companies are expected to play an important role in this process (NICOM CONSULTING 1996; BARTENS and MOSOLFF 1998, p.297).

The prospective EU integration as well as the domestic policy environment determine the investment climate for Western sugar companies in Poland. As early as 1989, the company British Sugar established the first joint venture with two Polish sugar factories (SUGARPOL 1996), and recently several German sugar processors started to purchase shares in Polish enterprises (ANONYMOUS 1997a; 1997b). The question arises of how beneficial FDI will be in the Polish sugar industry, i.e. in a situation where a distorting policy regulation like the current quota system is in place. It must be expected that, apart from obvious cost advantages, some companies invest in Poland only for rentseeking motivations, assuming that the EU quota system will be fully extended to the new member countries. Some authors even argue that, without extension of the quota system, it might be more profitable for Western sugar companies to serve the Polish market through exports from Western European production plants (SOMMER 1998, p.37). However, if the EU would not extend the sugar quota to the new members, the sugar regime would have to be modified in other directions. Guaranteed domestic prices highly above world market levels would not be sustainable, as several countries in Central Europe have already reached their tariff bindings and limits on subsidized exports for sugar under the regulations by the World Trade Organization (TWESTEN 1998).<sup>3</sup> For these reasons, an analysis of the interaction between FDI and various trade policies is relevant also in a long-term perspective.

## 6.3 A Theoretical Model of Foreign Direct Investment

In this section, the theoretical background is laid out for the following empirical analysis of FDI in the Polish sugar industry. FDI is modeled as an exogenous increase in the domestic capital stock which increases the local production capacity and shifts the domestic supply curve to the right. Simultaneously, output changes in the sugar market are translated into demand for sugar beets. Moreover, local competition effects due to FDI are implemented on the sugar beet market.

<sup>&</sup>lt;sup>3</sup> Poland is an exception, as tariff bindings for white sugar are above EU levels. With respect to export subsidies the situation is unclear due to measurement problems (TWESTEN 1998, p.131).
### **Production effects**

Figure 6.1 provides a graphical description of the model (CASSON and PEARCE 1986).

Figure 6.1: FDI without quantitative restrictions



Source: CASSON and PEARCE (1986).

There are two groups of suppliers, i.e. foreigners and locals. In the initial situation, local supply, depicted by curve *L*, is at  $q_0^L$ . This equals local demand, depicted by curve *D*, at a domestic price  $p_d$ , which is significantly above the world market price  $p_w$ . The difference between  $p_d$  and  $p_w$  is caused by the current protectionist policy regime. If, in a free trade scenario, the Polish sugar policy would be abolished, local supplies would fall to  $q_w^L$  and consumption would increase to  $q_w^D$ . It is assumed that the world market price would not be affected by Polish sugar imports. The standard welfare gains from removed protection would be obtained, i.e. a gain in consumer surplus which exceeds the loss in producer surplus.

FDI can occur either by building new plants and establishing foreign subsidiaries, or by purchasing shares of existing factories. In the model, these forms are treated uniformly. Any production with use of foreign capital is depicted by a sector supply curve F. Horizontal summation of curves F and L provides the total domestic supply curve G. If domestic price  $p_d$  would be guaranteed by a policy of import tariffs and export subsidies, combined production of foreign and local suppliers would be at  $q_t^G$ , and a

certain amount could be exported, albeit at the expense of export subsidies. In a free trade scenario with FDI, total domestic supply would be at  $q_w^G$ , and import demand would be reduced to  $(q_w^D - q_w^G)$  compared to free trade without FDI.

As already mentioned, the Polish sugar policy consists mainly of a quota system. With incoming FDI, the situation can be described as in Figure 6.2. Again, in the initial situation, local production and consumption are balanced at  $q_0^L$ . With inflowing FDI and total output being limited by the quota, marginal costs are falling. Local suppliers earn a quota rent of  $(p_d - MC) \cdot q_{Qu}^L$ , while foreign suppliers earn a quota rent of  $(p_d - MC) \cdot q_{Qu}^L$ , while foreign suppliers earn a quota to foreign producers.





Source: Adapted from CASSON and PEARCE (1986).

### **Competition effects**

In addition to the production effects, the competitive environment in the food industry of former centrally-planned economies is likely to improve in the presence of FDI.<sup>4</sup> Figure 6.3 shows how output and input markets are linked in the model, and how competition effects are implemented on the input market for sugar beets.



Figure 6.3: Linking output and input markets

Source: Own extension based on CASSON and PEARCE (1986).

In the Northeastern quadrant of Figure 6.3, the output market for sugar is shown as before, where q is the quantity of sugar and p the sugar price. To keep things simple,

<sup>&</sup>lt;sup>4</sup> This will lead to welfare gains for local farmers who supply raw inputs, like sugar beets in this case. Of course, it is also possible that the competitive situation in the recipient country deteriorates, if foreign firms dominate the domestic market and gain market power. This case, however, is not considered here.

there are no foreign suppliers in this diagram. The amount of sugar beets necessary for producing one ton of sugar can be expressed by a sugar beet transformation factor. In Figure 6.3, the slope of the line in the Northwestern quadrant corresponds to the size of the transformation factor. It can be different for local and foreign suppliers. The transformation factor is used for translating any output quantity of sugar into the corresponding input demand for sugar beets  $q^{sb}$ . The price for sugar beets is then determined at the level where input demand equals input supply which is given by curve *S*. If, for example in a free trade situation, the domestic sugar price drops from  $p_d$  to  $p_w$ , local sugar production will be reduced from  $q_0^L$  to  $q_w^L$ , and this will in turn lead to a decrease in the demand for sugar beets from  $q_0^{sb}$  to  $q_w^{sb}$ . How much the price for sugar beets will fall, depends on the slope of the supply curve *S*. In this case it drops from  $p_d^{sb}$  to  $p_w^{sb}$ .

In order to model imperfect competition in transition countries, certain simplifying assumptions have to be made. Therefore, the Polish sugar industry in the current situation is assumed to reveal oligopsonistic behavior, where processing firms have some market power over sugar beet suppliers. The degree of oligopsony power in an empirical model can be measured by the so-called Lerner index (LERNER 1934). The Lerner index in this case defines the difference between the value of marginal product and the market price of an input caused by imperfectly competitive behavior of firms on the demand side of the input market. This is to say that Polish sugar suppliers in an oligopsony receive a lower price for their sugar beets than under perfect competition. In Figure 6.3, curve *S'* represents the relevant input supply curve in an oligopsonistic market. Curve *S* would represent the case of perfect competition with no difference between  $p^{sb}$  and the value of marginal product for sugar beets. The Lerner index can be defined as: <sup>5</sup>

(1) 
$$L = \frac{H}{\varepsilon} \cdot (1 - \beta)$$

with: H = Herfindahl measure of processing firm concentration ( $0 \le H \le 1$ )

 $\varepsilon$  = sugar beet supply elasticity ( $\varepsilon > 0$ )

 $\beta$  = degree of collusion between processing firms ( $0 \le \beta \le 1$ ).

<sup>&</sup>lt;sup>5</sup> See Appendix A-6.1 for a mathematical derivation of the Lerner index and a definition of the Herfindahl measure of concentration.

It is implemented into the model as follows:

(2) 
$$p \cdot f_X = p^{sb} \cdot (1+L)$$

with:  $p \cdot f_X$  = value of marginal product of sugar beets

- $p^{sb}$  = price for sugar beets
- L = Lerner index.

In Appendix A-6.1 it is shown that *L* is equal to zero under perfect competition and to  $\frac{1}{\varepsilon}$  under complete collusion. Thus, the logical range of *L* is  $\frac{1}{\varepsilon} \ge L \ge 0$ . If  $\beta = 0$ , the case of a Cournot-type oligopsony applies. This will be assumed throughout the analysis in this paper (CHEN and LENT 1992, p.975). Hence, with a given input supply elasticity  $\varepsilon$  the Lerner index will change with the number of processing firms in the sector. If the number of firms increases, e.g. because additional foreign firms enter the market, *H* decreases and the difference between the value of marginal product and the input price is reduced. The Lerner index provides a simple way to implement competition effects in the empirical model described in Section 6.4.

#### **Optimal taxation and welfare effects**

Now the total welfare effect of FDI in the model has to be determined. Therefore, it is assumed that local policy-makers have the objective to maximize domestic welfare which can be defined as:<sup>6</sup>

 (3) Domestic Welfare = Local consumer surplus + local producer surplus + tax revenue from foreign profit taxation + tariff revenue.

Tax and tariff revenues accrue to the government budget. Tariff revenue is positive in an import situation and negative in an export situation. Local consumer and producer surplus as well as tariff revenue automatically contribute to domestic welfare. However, the existence of foreign suppliers adds another aspect to the total welfare calculation. If it is assumed, for simplicity, that foreign firms are completely owned by foreign shareholders, it is also straightforward to assume that they would usually try to

<sup>&</sup>lt;sup>6</sup> This is adapted from CASSON and PEARCE (1986, p.5).

repatriate all profits related to FDI activities back to their home country. Although the local government is able to capture part of the foreign profits through taxation, it cannot increase the tax level too much, as this would deter foreign investors entirely from entering the domestic market.

In the presented model, the local government and the potential foreign investors are assumed to interact strategically in a decision sequence that involves the following steps shown in Figure 6.4.<sup>7</sup>

StageDecisionAgent1.FDI vs. exportForeign investor2.Level of investmentForeign investor3.Level of taxationLocal government4.Level of outputForeign investor

Figure 6.4: Sequence of decisions by foreign investor and local government

Source: Adapted from BRANDER and SPENCER (1987, p.261).

In the first stage, the foreign firm decides whether to supply a foreign market through FDI or exports. Here it is assumed that this first decision is always made in favor of FDI. This can be justified in the case where prohibitive import restrictions are in place, like in the Polish sugar market. Second, the foreign firm decides about the amount of capital to be invested, i.e. the level of investment. Third, the host country government chooses a tax rate that maximizes domestic welfare as defined in equation (3). In the final stage, given the tax rate, the foreign firm determines its profit maximizing output.

For modeling purposes it is important to specify the tax instrument. In this case a specific output tax is used. As pointed out by BRANDER and SPENCER (1987, p.264), this is more appropriate than a profit tax due to credibility constraints in sequenced decision-making process. If a pure profit tax were used, the local government could tax away 100

<sup>&</sup>lt;sup>7</sup> The decision sequence is adapted from a model by BRANDER and SPENCER (1987).

percent of foreign profits once the investment were in place. No firm would undertake an investment under these conditions. Hence, it is assumed that the local government can confirm itself to the tax instrument, but the actual level is dependent on the policy regime and the level of investment. Under most circumstances, the optimal tax level is increasing in the amount of capital invested (BRANDER and SPENCER 1987, p.268).

Unlike the case where only local suppliers are on a domestic market, the optimal tax rate in this model is usually greater than zero. If there are foreign suppliers on the market, the local government can always tax away a certain share of the foreign producer surplus which otherwise would be repatriated abroad. On the other hand, output taxes act as a disincentive to production and reduce producer surplus and, hence, tax revenues. The problem for the local government is to find the optimal tax rate such as to maximize domestic welfare.<sup>8</sup>

#### 6.4 Structure and Calibration of the Empirical Model

Based on the theoretical model described in the last section, a partial equilibrium model is calibrated to the 1996 reference situation in the Polish sugar industry (Table 6.1). The empirical model is based on reduced-form Cobb-Douglas functions which are defined as follows:

- (4)  $q_d = a \cdot p_s^{\eta}$  (Sugar demand)
- (5)  $q_s = b \cdot (p_s t)^{\varepsilon_s} \cdot p_{sb}^{\varepsilon_{s,sb}}$  (Sugar supply)<sup>9</sup>
- (6)  $q_d^{sb} = \lambda \cdot q_s$  (Sugar beet demand)<sup>10</sup>
- (7)  $q_s^{sb} = c \cdot \left[ p_{sb} \cdot (1 L) \right]^{\varepsilon_{sb}}$  (Sugar beet supply)

with:  $q_d$ ,  $q_s$  = sugar demand, supply  $q_d^{sb}$ ,  $q_s^{sb}$  = sugar beet demand, supply  $p_s$  = sugar price

<sup>9</sup> The supply functions for local and foreign suppliers only differ in the size of the parameters.

<sup>&</sup>lt;sup>8</sup> In the empirical model, both foreign and local suppliers are charged with the output tax. This is justified by the fact that it is not distinguished between wholly-owned foreign subsidiaries and joint ventures. It could also be argued that a tax discrimination between locals and foreigners would not be sustainable.

<sup>&</sup>lt;sup>10</sup>The sugar beet transformation factor  $\lambda$  is higher for local than for foreign firms.

$p_{sb}$	= sugar beet price
t	= tax rate
L	= Lerner index of firm concentration
η	= own-price elasticity of sugar demand
$\mathcal{E}_{S}$	= own-price elasticity of sugar supply
$\mathcal{E}_{s,sb}$	= cross-price elasticity of sugar supply with respect to sugar beet price
$\mathcal{E}_{sb}$	= own-price elasticity of sugar beet supply
λ	= sugar beet transformation factor
a, b, c	= constant parameters.

In the calibration procedure, equations (4), (5), and (7) are solved for the constant terms by using initial values of prices, quantities, and the Lerner index as well as the given elasticities. Once the equations are calibrated, they can be used in further analyses for deriving price and quantity effects as well as welfare changes.<sup>11</sup>

Table 6.3 provides the initial data needed for calibrating the supply and demand functions.

Table 6.3:Initial data on the Polish sugar industry in 1996

Quantities in t		Parameters	
Local sugar demand:	1 700 000	Price elasticity of sugar demand:	- 0.2
Local sugar supply:	1 700 000	Price elasticity of sugar supply:	0.6
Sugar beet supply:	14 212 000	Price elasticity of sugar beet supply:	2
Prices in US\$/t		Cross price elasticity of sugar supply	0.1
Domestic sugar price:	545.0	with respect to beet price:	- 0.1
World market sugar price:	333.0	Number of local sugar firms:	4
Sugar beet price:	25.4		

Sources: RONINGEN et al. (1991); BARTENS and MOSOLFF (1996); DEVADOSS and KROPF (1996); WALKENHORST (1997); SOMMER (1998).

Local production and consumption of sugar is set at 1.7 million tons. The amount of sugar beets necessary for producing this quantity of sugar is derived with the sugar beet transformation factor. For Polish sugar factories in the current situation the

<sup>&</sup>lt;sup>11</sup>The welfare measures can be calculated by using the curve integrals. However, since the supply for sugar beets in the model is linked to the production of sugar, double-counting of producer surplus on the input and output market has to be ruled out.

transformation factor is 8.36 (WALKENHORST 1997, p.10). The domestic sugar price in Poland is about 64 percent above the world market price. The import tariff rate is set at 212 US\$ per ton.

Supply and demand elasticities for sugar in market economies can be found in RONINGEN et al. (1991) and DEVADOSS and KROPF (1996). However, there is considerable uncertainty about the size of these elasticities in transition countries. The initial values given in Table 6.3 are rather high compared to average elasticities e.g. for the EU. This can be justified by the fact that the structure of consumption as well as production is constantly changing in the process of transition. Sugar demand might be more elastic than in mature market economies as new substitutes for sugar become available. The restructuring process on the supply side might also justify slightly higher elasticities than can be found in the literature. The supply elasticity for sugar beets is taken from WALKENHORST (1997). All elasticity parameters should be subject to profound sensitivity analysis, which has been done by lowering all the parameters with the exception of the demand elasticity. Parameter values and model results for this case are provided in Appendix A-6.3.

A supply function also has to be specified for foreign firms which are not in the market in the initial situation. The supply elasticity of foreign suppliers is initially also set at 0.6. In Table 6.2 it has been shown that productivity in Western European sugar industries is considerably higher than in Poland. Hence, for calibrating the foreign supply function it is assumed that, using the same amount of inputs, foreign supply at the initial domestic price would be 150 percent of current local supply. The sugar beet transformation factor for foreign firms is assumed to be 7.5 (WALKENHORST 1997, p.10).

In order to model the competition effect of FDI, the number of firms on the market has to be specified. As already mentioned, in the 1994 Sugar Act the 76 sugar factories currently operating in Poland were grouped into 4 holdings to be privatized in the near future. For simplicity, this is taken as the initial number of identical local firms in the model. Hence, the Herfindahl measure of firm concentration takes the value of 0.25.<sup>12</sup> Assuming Cournot-type behavior, i.e. the parameter  $\beta$  in equation (2) is equal to zero, and taking a supply elasticity for sugar beets of 2, the initial value of the Lerner index is

<sup>&</sup>lt;sup>12</sup>See Appendix A-6.1 for calculation of the Herfindahl measure.

0.125. This is to say that the current price of sugar beets received by farmers is 12.5 percent lower than it would be under perfect competition. The pro-competitive effect of FDI is then introduced by 4 additional foreign firms entering the industry.<sup>13</sup>

Finally, the decision of foreign firms about the level of investment has to be specified. Since capital input is not explicitly considered in the model, the level of FDI is defined in terms of the relative share of foreign assets in the local production capacity. To reflect the general investment climate in the Polish sugar industry, two different risk scenarios are defined. In the high-risk scenario, the ratio of FDI to the local capital stock is assumed to be low at 0.1. This means the current capital stock in the Polish sugar industry is increased by 10 percent through FDI by Western sugar companies. In the low-risk scenario, the ratio of FDI to the assumption that a third of all sugar factories would be wholly owned by foreign investors. Alternatively, and probably more realistically, this is to say that in two thirds of the Polish sugar factories foreign firms would have a 50 percent share.<sup>14</sup>

### 6.5 Policy Scenarios and Selected Results

The major objective of the empirical analysis is to model the interaction between FDI, various types of trade policy intervention, and imperfect competition. For this purpose, four policy scenarios are defined under which FDI may occur in the Polish sugar industry. The scenarios range from a very restrictive domestic production quota to free trade. In addition, a free trade scenario *without* FDI is also simulated which serves as a benchmark with respect to the welfare effects of the FDI scenarios.

- 1. <u>No FDI (free trade)</u>: all policy interventions in the Polish sugar sector are removed; no FDI occurs.
- 2. <u>FDI with output quota</u>: this is the current policy regime where the overall quantity of sugar remains fixed at initial levels, thus keeping the domestic price 64 percent above the world market level.

<sup>&</sup>lt;sup>13</sup>A total number of firms between 4 and 8 in the Polish sugar market seems not unrealistic given other model results in the literature. For example, in a plant-location model of the Polish sugar industry, WALKENHORST (1997) derives the result that, after large-scale restructuring, only 13 factories of an efficient size might stay in operation.

<sup>&</sup>lt;sup>14</sup>A share of about 50 percent is often found in joint-venture arrangements. The maximum share of foreign capital in the overall local capital stock would probably be at 0.5, since many countries do not accept a majority stake of foreigners in their industries.

- 3. <u>FDI with fixed domestic price</u>: the domestic sugar price is held fixed at the current level through variable import levies and export subsidies; local producers are protected from imports.
- 4. <u>FDI with deficiency payment</u>: producers receive the difference between world market price and guaranteed domestic price from the government, while consumers pay the lower world market price; local producers are protected from imports.
- 5. <u>FDI with free trade</u>: this is the same as in scenario 1, but here FDI is introduced.

In order to capture competition effects, all the scenarios where FDI actually occurs are calculated with and without a reduction in the Lerner index on the sugar beet market. Furthermore, all FDI scenarios are calculated under the high-risk as well as the low-risk assumption.<sup>15</sup>

In each scenario, the interaction in decision-making between the host country government and the foreign investor works as follows. First, the decision on the level of investment is made according to risk assumptions. Second, the government chooses a tax rate that maximizes domestic welfare. Finally, the foreign firm decides on the optimal output given the tax rate. An equilibrium is obtained when there is neither an incentive for the government to increase the tax nor an incentive for the foreign firm to change output. The model results are then compared with the status quo in 1996 as the reference situation.

Table 6.4 shows model results for the high-risk case with a foreign capital share of 0.1 and no competition effects through FDI, i.e. the Lerner index stays at the initial rate of 0.125. In the free trade scenario without FDI, the local sugar price drops by 39 percent and, hence, consumption rises by about 10 percent. Sugar production by local firms is sharply reduced, and about a third of local sugar consumption has to be imported. Lower domestic sugar production also causes the demand for sugar beets to fall, which in turn leads to lower beet prices for farmers. If FDI occurs under free trade, local sugar production falls even more, by about a third compared to the reference situation. Imports are even slightly higher than in the scenario without FDI, since the government imposes a tax which has an output reducing effect. In the three protectionist scenarios,

<sup>&</sup>lt;sup>15</sup>This yields in total 16 scenarios with FDI, plus the benchmark free trade scenario without FDI.

the fall in local sugar production is less severe. About 13 percent of total domestic output is provided by foreign firms. Since these firms have a lower beet transformation factor, sugar beet production is slightly reduced in the quota and fixed price scenario, even though total sugar production remains unchanged.

### Table 6.4:Price and quantity effects of FDI in the Polish sugar industry under<br/>various policy scenarios<sup>a</sup>

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 283	1 478	1 478	1 631	1 091
% change		- 24.5	- 13.1	- 13.0	- 4.0	- 35.8
Foreign supply			222	222	245	164
Trade <sup>b</sup>		- 593	0	0	0	- 621
Sugar beet price	25.4	22.1	25.2	25.2	26.5	21.7
% change		- 13.1	- 0.7	- 0.7	4.3	- 14.7
Sugar beet supply	14 212	10 725	14 020	14 021	15 473	10 352
% change		- 24.5	- 1.4	- 1.3	8.9	- 27.2

(FDI share = 0.1; no competition effects; Lerner index = 0.125)

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

Table 6.5 presents the welfare effects related to the changes just discussed. Consumers clearly gain from lower prices in the free trade scenarios as well as under the deficiency payment scheme. The most favorable scenario for sugar producers as well as sugar beet farmers is the deficiency payment system. However, this is only achieved by considerable budget expenditures for compensating the price difference between world and domestic markets. Total domestic welfare improves by 72 million US\$ in the case of free trade with FDI, which is equivalent to about 8 percent of the total consumer expenditure on sugar. These maximum welfare gains are relatively small which is due to the high-risk assumption with an FDI share of only 10 percent. However, the quota system as the most restrictive policy scenario achieves only gains of 10 million US\$, and under a deficiency payment system domestic welfare is even slightly reduced by 12

million US\$.<sup>16</sup> The optimum tax rate is lowest in the deficiency payment case and highest with about 24 percent in the free trade scenario with FDI. Sugar beet producers' surplus falls by about 9 percent of their initial revenue in both free trade scenarios, but remains almost unchanged in the scenarios with high sugar prices.

### Table 6.5:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios, in million US\$

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 316	- 140	- 181	- 54	- 407
Foreign producer surplus		52	46	60	20
Sum of domestic welfare	63	10	13	- 12	72
% of total sugar expenditure	6.8	1.1	1.4	- 1.3	7.8
Beet producer surplus	- 31	- 2	- 2	12	- 34
% of total revenue	- 8.6	- 0.5	- 0.5	3.4	- 9.5
Tax level (% of sugar price)		16.1	20.9	6.0	23.8

(FDI share = 0.1; no competition effects; Lerner index = 0.125)

Source: Own calculations.

In the next set of calculations, positive competition effects through FDI are taken into account. This means, with given elasticity parameters, the Lerner index is reduced to 0.0625, i.e. the gap between the value of marginal product and the producer price for sugar beets is reduced from 12.5 to 6.25 percent. The quantity effects on the sugar market are generally very similar to the scenarios without increased competition.<sup>17</sup> Similarly, the overall welfare effects as shown in Figure 6.5 are not much affected by the changes in the competitive behavior of the sugar companies. In both cases, FDI under the deficiency payment scheme causes a slight welfare loss. This is due to the fact that the optimal tax rate is comparatively low, i.e. a higher share of foreign producer surplus is transferred abroad and, hence, does not accrue to the local budget.

<sup>&</sup>lt;sup>16</sup>In the scenarios *fixed domestic price* and *deficiency payment*, the tax rate is only increased subject to a balanced trade situation. Although in the model a further tax increase would be welfare improving, as cheap imports could be substituted for high-price domestic production, this would contradict the intention of the trade policy. It is assumed that trade policies were initially introduced in order to protect domestic producers from import competition.

<sup>&</sup>lt;sup>17</sup>The detailed results are given in Appendix A-6.2.

Figure 6.5: Total domestic welfare effects of FDI with and without changes in competition (FDI share = 0.1)



Source: Own calculations.





Source: Own calculations.

Despite the fact that overall domestic welfare effects from improved competition are negligible, sugar beet producers gain remarkably from higher beet prices. While their surplus still falls by 21 million US\$ in the free trade case with FDI, it increases by 19 million US\$ under the quota and the fixed-price regime, and even by 36 million US\$ in the deficiency-payment scenario (Figure 6.6). This additional gain does not change the total welfare effect, because the reduction in the oligopsony rent is mainly a reallocation of income from sugar producers to sugar beet farmers.<sup>18</sup> While the deficiency payment system is the least desirable scenario from the host country's point of view, it is the welfare maximizing option for sugar processors as well as sugar beet farmers.<sup>19</sup>

All results presented so far have dealt with scenarios under the high-risk assumption where the foreign investment share is rather low. In order to compare the high-risk with the more optimistic low-risk case, Figure 6.7 shows the total domestic welfare effects for both FDI shares of 0.1 as well as 0.5.<sup>20</sup> Only the scenarios with positive competition effects are considered, as total domestic welfare is again hardly affected by changes in competition.

Figure 6.7: Total domestic welfare effects of FDI under high and low-risk scenarios, with positive competition effects



Source: Own calculations.

<sup>&</sup>lt;sup>18</sup>This result is partly determined by the size of the cross-price elasticity of sugar supply with respect to the beet price which was set at - 0.1. The potential effect of a larger cross-price elasticity has not been considered in this paper.

<sup>&</sup>lt;sup>19</sup>See Table A-6.2.2 in Appendix A-6.2.

<sup>&</sup>lt;sup>20</sup>The corresponding price and quantity changes can be found in Appendix A-6.2.

In the low-risk case, domestic welfare strongly increases in all policy scenarios. However, the ranking of the policy instruments from the host country's perspective changes. With a higher FDI share, the less restrictive policy options become more attractive. The deficiency payment system now yields about 86 percent of the welfare gain under free trade. The quota system leads to only half the gains compared to the other policy options.<sup>21</sup>

Local sugar processors lose considerably in all scenarios, as they are partly driven out of the market by their foreign competitors. Figure 6.8 shows the corresponding changes in producer surplus. As mentioned above, the ranking of the policy scenarios from their point of view is reversed as compared to the overall host country's perspective. With a low level of FDI, the deficiency payment scheme is the most favorable option for local sugar processors, while the quota causes the smallest losses when foreign involvement in the sector is strong. In this case, the quota rent accounts for a much bigger share in producer surplus.





Source: Own calculations.

<sup>&</sup>lt;sup>21</sup>In the free trade scenario with a high level of FDI, imports are reduced by about a half compared to the high-risk case and the scenario without FDI. This shows that, at current world market price levels, Poland would not be able to export sugar, even in the case with relatively high FDI inflows. See Table A-6.2.5 in Appendix A-6.2 for the detailed results.

The quota system is also the most preferred option for foreign sugar processors. While the three protectionist scenarios lead to similar gains for foreign companies in the highrisk scenarios, the gains under the quota regime more than triple in the low-risk case (Figure 6.9). This makes the most restrictive policy measure with the related quota rents the most attractive option for foreign producers who invest in the Polish sugar market. The results support the view discussed earlier that some Western companies might only have started to buy shares in Polish sugar factories in order to secure market shares under a future quota system in an enlarged EU.

Figure 6.9: Producer surplus of foreign sugar processors from FDI under high and low-risk scenarios, with positive competition effects



Source: Own calculations.

Finally, the optimal tax rates are provided for the high as well as low-risk scenarios (Figure 6.10). The optimum tax rate more than doubles in all scenarios with a high level of FDI. Due to higher foreign participation in the sector, the government is able to capture a bigger share of producer income through taxation. In addition to the gains in consumer welfare from lower sugar prices, i.e. in the case of deficiency payments and free trade, the tax revenue accounts for the positive domestic welfare effects as shown in Figure 6.7. In the model, so far only a simple output tax has been considered due to credibility constraints in the decision-making process. More realistic tax instruments

might change the ability of the local government to capture parts of the foreign producer surplus.<sup>22</sup>



Figure 6.10: Optimal tax rate under high and low-risk scenarios, with positive competition effects

Source: Own calculations.

The model results for the sensitivity analysis with lower supply elasticity parameters are provided in Appendix A-6.3. The quantity effects are similar to the results already discussed, with the exception of local sugar supply, which is, due to lower elasticity values, much less reduced in the free trade scenarios. The ranking of the scenarios with respect to local and foreign producer surplus as well as total domestic welfare remains the same. The range of domestic welfare effects is wider in the sensitivity analysis, as the highest total gains under free trade are only 55 million US\$ in the high-risk case, while they are more than 190 million US\$ in the low-risk scenarios. Sugar beet farmers are generally better off in the sensitivity analysis with lower parameter values.

### 6.6 Conclusions

Inefficient processing industries in Central European transition countries in many cases act as bottlenecks for the development of competitive agricultural and food sectors.

<sup>&</sup>lt;sup>22</sup>The impact of different tax instruments on the outcome of the decision sequence between the government and the foreign investor is left for further research.

State involvement often is still high, privatization procedures are slow, and in some countries protectionist trade policies have been implemented in order to increase the profitability of inefficient local food processors (OECD 1996). On the other hand, expectations are high that FDI activities will contribute significantly to privatization and restructuring of these industries. Therefore, all transition countries try to establish a stable institutional framework and favorable investment conditions in order to attract foreign firms.

In this paper, a simple agricultural sector model has been developed for analyzing the effects of FDI in the presence of protectionist trade policies as well as market imperfections. The interaction between a potential foreign investor and the local government is represented by a decision sequence, in which output taxes and the level of investment are crucial variables. It is also taken into account that processing firms in transition countries often have some market power over their input suppliers in the farm sector. Market entrance of foreign firms is likely to change the competitive environment to the favor of local agriculture. The model is applied to the Polish sugar sector where a quota system similar to EU regulations was introduced in 1994.

The model simulations show that the policy environment matters very much with respect to the potential impact of FDI in the Polish sugar industry, while the procompetitive effect of foreign entrants seems to be less important. It is not the case that the same positive welfare effect of FDI occurs regardless of any trade policy distortions on the local market. While significant welfare gains can be derived if FDI occurs in a free trade scenario, under more restrictive policies domestic welfare might even decrease, if investment risk is high and FDI inflows are small. A quota system is certainly one of the least desirable policy options from the host country's perspective. If FDI occurs under quantitative restrictions, foreign firms capture a significant share of the quota rent, which can be only partly taxed away by the government. On the other hand, sugar producers are better off in the quota scenario than under any other policy regime, if the share of FDI in the local industry is relatively high. For sugar beet farmers, a deficiency payment scheme is the most favorable option in which the highest overall output of sugar occurs. The model results clearly show that the potential positive impact of FDI on the host country's economy is considerably reduced in the presence of distorting trade policies.

The pro-competitive effect of FDI on the input market for sugar beets only accounts for a small additional gain in domestic welfare. Although the price increase for sugar beets contributes to a higher producer surplus for farmers, this is primarily a reallocation of income from the processing firms. However, in some cases the change in sugar beet producers' surplus more than doubles due to increased competition. In other cases a slight loss is converted into a significant gain.

The model developed in this paper should be applicable to other industries in transition countries, as it is fairly simple and not too demanding in terms of data requirements. The results are straightforward and may be easy to communicate to policy-makers. However, there is certainly scope for further improvements. First, elasticity parameters are not very reliable during the transition process and further sensitivity analysis is required. Second, the implementation of imperfect competition in the current model might be over-simplified in a situation in which market imperfections are rather caused by strong government involvement than by oligopsonistic behavior of processing firms. This needs further refinement. Third, instead of setting the amount of FDI exogenously, the decision by foreign firms between FDI in or exports to a certain country should be endogenized in the model. This also implies an explicit decision with respect to the level and the actual type of investment, i.e. the choice between wholly-owned subsidiaries and joint-venture agreements. Moreover, a dynamic version of the model would probably be more appropriate for the analysis of FDI in a rapidly changing transition economy. Finally, issues like technology transfer and local employment effects have been neglected so far. Nevertheless, the present model may still provide some valuable insights into the interaction between FDI, distorting trade policies and imperfect competition.

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### Appendix A-6.1 Derivation of the Lerner Index for the Case of an Oligopsony

The derivation of the Lerner index for this paper is adopted from CHEN and LENT (1992). It starts with a single processing firm's profit function:

(1) 
$$\Pi_i = p \cdot q_i - w_x \cdot x_i - w_m \cdot m_i ,$$

with:  $\Pi_i$  = profit of firms *i* 

p = price of output, e.g. sugar

 $q_i$  = output quantity

 $w_x$  = input price for raw input *x*, e.g. sugar beets

 $x_i$  = quantity of raw input used by firm *i* 

 $w_m$  = price for other inputs

 $m_i$  = quantity of other inputs.

One of the first order conditions of profit maximization for each firm is

(2) 
$$\frac{\partial \Pi_i}{\partial x_i} = p \cdot \frac{\partial q_i}{\partial x_i} - w_x - x_i \cdot \frac{\partial w_x}{\partial x_i}$$

Setting this expression equal to zero and rearranging yields

(3) 
$$p \cdot f_x = w_x + x_i \cdot \frac{\partial w_x}{\partial x_i}$$
,

with  $f_x$  as the first derivative of  $q_i$  with respect to  $x_i$ . Any processing firm *i* faces an inverse input market supply function

(4) 
$$w_x = g(X)$$
,

with  $X = \sum x_i = x_1 + x_2 + ... + x_n$ , i.e. the sum of raw inputs purchased by all processing firms.

The first derivative of  $w_x$  with respect to  $x_i$  yields

(5) 
$$\frac{\partial w_x}{\partial x_i} = \frac{\partial w_x}{\partial X} \cdot \frac{\partial X}{\partial x_i} \cdot \frac{X}{X} \cdot \frac{w_x}{w_x}$$
.

This can be rearranged to

(6) 
$$\frac{\partial w_x}{\partial x_i} = \frac{\partial w_x}{\partial X} \cdot \frac{X}{w_x} \cdot \frac{\partial X}{\partial x_i} \cdot \frac{w_x}{X}$$
,

which is equivalent to

(7) 
$$\frac{\partial w_x}{\partial x_i} = \frac{1}{\varepsilon} \cdot \frac{\partial X}{\partial x_i} \cdot \frac{w_x}{X}$$
,

with  $\varepsilon$  being the price elasticity of market supply for input *x*.

Now (3) and (7) can be combined and  $w_x$  can be factored out to get

(8) 
$$p \cdot f_x = w_x \cdot \left(1 + \frac{1}{\varepsilon} \cdot \frac{x_i}{X} \cdot \frac{\partial X}{\partial x_i}\right)$$
.

The derivative of X with respect to a single firm's quantity  $x_i$  is equivalent to 1 minus the sum of derivatives of all other firms' quantities  $x_i$  with respect to  $x_i$ :

(9) 
$$\frac{\partial X}{\partial x_i} = 1 - \sum \frac{x_j}{x_i} = 1 - \beta_i$$
,

where  $\beta_i$  is the conjectural variation parameter reflecting the degree of collusion between firms. It can take values between 0 and 1. Then, equation (8) is multiplied by  $\frac{x_i}{X}$ :

(10) 
$$\frac{x_i}{X} \cdot p \cdot f_x = w_x \cdot \left(\frac{x_i}{X} + \frac{1}{\varepsilon} \cdot \frac{x_i^2}{X^2} \cdot \frac{\partial X}{\partial x_i}\right)$$
,

sum up over *i* and substitute in  $(1-\beta_i)$  from equation (9):

(11) 
$$\sum \frac{x_i}{X} \cdot p \cdot f_x = w_x \cdot \left( \sum \frac{x_i}{X} + \frac{1}{\varepsilon} \cdot \sum \left( \frac{x_i^2}{X^2} \cdot (1 - \beta_i) \right) \right)$$
.

The term  $\sum \frac{x_i^2}{X^2}$  is factored out in the last part of equation (11) which can be rewritten as

(12) 
$$p \cdot f_X = w_x \cdot \left(1 + \frac{1}{\varepsilon} \cdot \sum \frac{x_i^2}{X^2} \cdot \left(1 - \frac{\sum x_i^2 \beta_i}{\sum x_i^2}\right)\right)$$
,

where  $p \cdot f_X$  is now the weighted average of marginal products of raw input in the market. Two expressions in equation (12) can now be redefined. First, the Herfindahl index *H* as a measure of market concentration is  $H = \sum \frac{x_i^2}{X^2}$  (CHEN and LENT 1992, p.974). Second, the weighted average of conjectural variations  $\beta = \frac{\sum x_i^2 \beta_i}{\sum x_i^2}$  reflects the degree of collusion in the market. Using *H* and  $\beta$ , equation (12) can be simplified to

(13) 
$$p \cdot f_X = w_x \cdot \left(1 + \frac{H}{\varepsilon} \cdot (1 - \beta)\right)$$
.

The degree of market power in a certain industry can be stated as a composite Lerner index:

(14) 
$$L = \frac{H}{\varepsilon} \cdot (1 - \beta)$$
,

which simplifies equation (13) even further to

$$(15) \quad p \cdot f_X = w_x \cdot (1+L) \quad .$$

Thus *L* defines the difference between the value of marginal product and the market price for the raw input which is due to concentration of oligopsonistic processing firms. Depending on the values for *H* and  $\beta_i$ , several cases of market power can be distinguished:

- 1. Under *perfect competition* L = 0, as firms' concentration H approaches zero and/or the supply elasticity  $\varepsilon$  becomes infinitely high.
- 2. In the *monopoly* case, H = 1 and  $\beta_i = 0$ , hence L takes the value of  $\frac{1}{\varepsilon}$ .
- 3. Alternatively, several firms can act like a monopoly which is the case of *complete* collusion. L again is equal to  $\frac{1}{\varepsilon}$ , but it can be shown that in this case  $\beta_i$  is proportional to firms' relative market share  $\frac{x_i}{X}$ , which yields  $H \cdot (1 \beta) = 1$  (CHEN and LENT 1992, p.978).

4. Finally, there is the case of a Cournot-type oligopsony where  $\beta_i = 0$  and H < 1. This is the case applied in the simulations for this paper. The Lerner index *L* is determined by the measure of concentration *H* and the supply elasticity for raw inputs  $\varepsilon$ . If all firms in the market have the same market share, *H* is equal to the inverse of the number of firms.

### Appendix A-6.2 Further Model Results with Initial Parameters

### Table A-6.2.1:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios<sup>a</sup>

r	1					
	Reference	No FDI	Quota	Fixed	Deficiency	Free trade
	1996	(free trade)		domestic	payment	
				price		
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 269	1 478	1 478	1 631	1 089
% change		- 25.4	- 13.0	- 13.0	- 4.0	- 35.9
Foreign supply		0	222	222	245	163
Trade <sup>b</sup>		- 607		0	0	- 623
Sugar beet price	25.4	24.7	26.7	26.7	28.1	22.9
% change		- 2.8	5.2	5.2	10.5	- 9.7
Sugar beet supply	14 212	10 606	14 021	14 021	15 473	10 331
% change		- 25.4	- 1.3	- 1.3	8.9	- 27.3

(FDI share = 0.1; positive competition effects; Lerner index = 0.0625)

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

### Table A-6.2.2:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios in million US\$

(FDI share = 0.1; positive competition effects; Lerner index = 0.0625)

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 315	- 140	- 174	- 46	- 404
Foreign producer surplus	0	51	46	60	20
Sum of domestic welfare	64	10	12	- 13	72
% of total sugar expenditure	6.9	1.1	1.3	- 1.4	7.8
Beet producer surplus	- 3	19	19	36	- 21
% of total revenue	- 0.8	5.3	5.3	10.1	- 5.9
Tax level (% of sugar price)		16.1	20.1	5.1	23.4

	(FDI share = $0.5$ ; no competition effects; Lerner index = $0.125$ )					
	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 283	971	971	1 072	881
% change		- 24.5	- 42.9	- 42.9	- 36.9	- 48.2
Foreign supply		0	729	729	804	660
Trade <sup>b</sup>		- 593		0	0	- 335
Sugar beet price	25.4	22.1	24.8	24.8	26.1	23.6
% change		- 13.1	- 2.2	- 2.2	2.7	- 6.9
Sugar beet supply	14 212	10 725	13 585	13 585	14 992	12 316
% change		- 24.5	- 4.4	- 4.4	5.5	- 13.3

Table A-6.2.3:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios<sup>a</sup>

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

### Table A-6.2.4: Welfare effects of FDI in the Polish sugar industry under various policy scenarios in million US\$

(1 D1  share = 0.3;  no competition effects; Leffier index = 0.123)						
	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade	
Consumer surplus	379			379	379	
Local producer surplus	- 316	- 243	- 443	- 404	- 471	
Foreign producer surplus	0	184	75	98	58	
Sum of domestic welfare	63	66	121	124	144	
% of total sugar expenditure	6.8	7.1	13.0	13.4	15.5	
Beet producer surplus	- 31	- 6	- 6	8	- 17	

- 1.6

33.3

- 1.6

60.8

2.1

53.4

- 4.8

46.0

- 8.6

(FDI share = 0.5; no competition effects; Lerner index = 0.125)

Source: Own calculations.

Tax level (% of sugar price)

% of total revenue

### Table A-6.2.5:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios<sup>a</sup>

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 269	971	971	1 072	876
% change		- 25.4	- 42.9	- 42.9	- 36.9	- 48.5
Foreign supply		0	729	729	804	657
Trade <sup>b</sup>		- 607		0	0	- 344
Sugar beet price	25.4	24.7	26.3	26.3	27.6	25.0
% change		- 2.8	3.5	3.5	8.7	- 1.7
Sugar beet supply	14 212	10 606	13 585	13 585	14 992	12 244
% change		- 25.4	- 4.4	- 4.4	5.5	- 13.8

(FDI share = 0.5; positive competition effects; Lerner index = 0.0625)

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

### Table A-6.2.6:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios in million US\$

(FDI share = 0.5; positive competition effects; Lerner index = 0.0625)

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 315	- 243	- 440	- 400	- 470
Foreign producer surplus	0	183	75	98	57
Sum of domestic welfare	64	66	120	123	143
% of total sugar expenditure	6.9	7.1	12.9	13.3	15.5
Beet producer surplus	- 3	14	14	31	- 1
% of total revenue	- 0.8	3.9	3.9	8.5	- 0.3
Tax level (% of sugar price)		33.3	60.4	53.0	46.0

### Appendix A-6.3 Sensitivity Analysis with Modified Parameters

Table A-6.3.1:	Data for model calibration in the sensitivity analysis
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Quantities in t		Parameters	
Local sugar demand:	1 700 000	Price elasticity of sugar demand:	- 0.20
Local sugar supply:	1 700 000	Price elasticity of sugar supply (local):	0.15
Sugar beet supply:	14 212 000	Price elasticity of sugar supply (foreign):	0.30
Prices in US\$/t		Price elasticity of sugar beet supply:	1
Domestic sugar price:	545.0	Cross price elasticity of sugar supply	
World market sugar price:	333.0	with respect to beet price:	- 0.05
Sugar beet price:	25.4	Number of local sugar firms:	4

Sources: RONINGEN et al. (1991); BARTENS and MOSOLFF (1996); DEVADOSS and KROPF (1996); WALKENHORST (1997); SOMMER (1998).

### Sensitivity analysis results for the high-risk case

# Table A-6.3.2:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios (Sensitivity analysis)<sup>a</sup><br/>(FDI share = 0.1; no competition effects; Lerner index = 0.25)

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 585	1 501	1 501	1 638	1 420
% change		- 6.8	- 11.7	- 11.7	- 3.6	- 16.5
Foreign supply		0	199	199	238	177
Trade <sup>b</sup>		- 291	0			- 279
Sugar beet price	25.4	23.7	25.1	25.1	27.7	23.6
% change		- 6.8	- 1.2	- 1.2	8.9	- 7.1
Sugar beet supply	14 212	13 249	14 041	14 041	15 479	13 198
% change		- 6.8	- 1.2	- 1.2	8.9	- 7.1

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

## Table A-6.3.3:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios in million US\$ (Sensitivity analysis)(EDI share = 0.1: no compatition affects: Lerner index = 0.25)

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 348	- 319	- 493	- 178	- 601
Foreign producer surplus	0	56	34	76	21
Sum of domestic welfare	31	20	31	3	55
% of total sugar expenditure	3.3	2.1	3.3	0.4	5.9
Beet producer surplus	- 18	- 3	- 3	25	- 19
% of total revenue	- 4.9	- 0.9	- 0.9	7.0	- 5.2
Tax level (% of sugar price)		36.6	56.5	19.6	52.0

(FDI share = 0.1; no competition effects; Lerner index = 0.25)

# Table A-6.3.4:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios (Sensitivity analysis)<sup>a</sup><br/>(FDI share = 0.1; positive competition effects; Lerner index = 0.125)

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 576	1 500	1 500	1 637	1 412
% change		- 7.3	- 11.7	- 11.7	- 3.7	- 17.0
Foreign supply		0	200	200	239	176
Trade <sup>b</sup>		- 300		0	0	- 288
Sugar beet price	25.4	26.2	27.9	27.9	30.7	26.1
% change		3.0	9.8	9.8	21.0	2.6
Sugar beet supply	14 212	13 176	14 040	14 040	15 478	13 122
% change		- 7.3	- 1.2	- 1.2	8.9	- 7.7

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

## Table A-6.3.5:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios in million US\$ (Sensitivity analysis)(EDI share = 0.1: positive competition effects: Lerner index = 0.125)

(FDI sna	re = 0.1; positive competition effects; Lerner index = 0.125)

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 347	- 320	- 481	- 155	- 600
Foreign producer surplus	0	56	36	78	20
Sum of domestic welfare	32	20	30	1	55
% of total sugar expenditure	3.4	2.2	3.2	0.1	5.9
Beet producer surplus	15	36	36	73	14
% of total revenue	4.3	9.9	9.9	20.2	3.9
Tax level (% of sugar price)		36.7	55.1	17.1	52.2

### Sensitivity analysis results for the low-risk case

# Table A-6.3.6:Price and quantity effects of FDI in the Polish sugar industry<br/>under various policy scenarios (Sensitivity analysis)<sup>a</sup><br/>(FDI share = 0.5; no competition effects; Lerner index = 0.25)

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 585	1 134	1 134	1 219	1 306
% change		- 6.8	- 33.3	- 33.3	- 28.3	- 23.2
Foreign supply		0	566	566	657	758
Trade <sup>b</sup>		- 291		0	0	188
Sugar beet price	25.4	23.7	24.5	24.5	27.0	29.7
% change		- 6.8	- 3.4	- 3.4	6.4	16.8
Sugar beet supply	14 212	13 249	13 725	13 725	15 118	16 602
% change		- 6.8	- 3.4	- 3.4	6.4	16.8

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

## Table A-6.3.7:Welfare effects of FDI in the Polish sugar industry under various<br/>policy scenarios in million US\$ (Sensitivity analysis)(EDI share = 0.5: no compatition affects: Lerner index = 0.25)

	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 348	- 406	- 721	- 707	- 671
Foreign producer surplus	0	141	15	29	54
Sum of domestic welfare	31	81	144	183	192
% of total sugar expenditure	3.3	8.8	15.5	19.8	20.7
Beet producer surplus	- 18	- 9	- 9	18	49
% of total revenue	- 4.9	- 2.5	- 2.5	4.9	13.7
Tax level (% of sugar price)		52.6	93.4	88.9	70.3

(FDI share = 0.5; no competition effects; Lerner index = 0.25)

### Table A-6.3.8: Price and quantity effects of FDI in the Polish sugar industry under various policy scenarios (Sensitivity analysis)<sup>a</sup> (FDI share = 0.5; positive competition effects; Lerner index = 0.125)

	Reference 1996	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Sugar price	545	333	545	545	545	333
% change		- 38.9				- 38.9
Sugar demand	1 700	1 876	1 700	1 700	1 876	1 876
% change		10.4			10.4	10.4
Local supply	1 700	1 576	1 132	1 132	1 217	1 300
% change		- 7.3	- 33.4	- 33.4	- 28.4	- 23.5
Foreign supply		0	568	568	659	755
Trade <sup>b</sup>		- 300	0		0	179
Sugar beet price	25.4	26.2	27.3	27.3	30.0	32.8
% change		3.0	7.3	7.3	18.2	29.2
Sugar beet supply	14 212	13 176	13 724	13 724	15 117	16 531
% change		- 7.3	- 3.4	- 3.4	6.4	16.3

<sup>a</sup> Prices are in US\$/t, quantities are in 1000 t.

<sup>b</sup> Negative values indicate imports.

Source: Own calculations.

#### Table A-6.3.9: Welfare effects of FDI in the Polish sugar industry under various policy scenarios in million US\$ (Sensitivity analysis) 0

FDI share $= 0.5$ ; positive	competition effects;	Lerner index =	0.125)
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	No FDI (free trade)	Quota	Fixed domestic price	Deficiency payment	Free trade
Consumer surplus	379			379	379
Local producer surplus	- 347	- 406	- 719	- 704	- 669
Foreign producer surplus	0	141	15	30	54
Sum of domestic welfare	32	81	144	183	191
% of total sugar expenditure	3.4	8.8	15.6	19.7	20.6
Beet producer surplus	15	28	28	63	102
% of total revenue	4.3	7.8	7.8	17.5	28.3
Tax level (% of sugar price)		52.7	93.2	88.6	70.2