Assessing the Impacts of Agricultural Policies on the Global, National and Farm level

- A Survey of Model Systems –

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1 Introduction

General and partial equilibrium models are the preferred choice as a framework in the analysis of agricultural policies, particularly of the WTO negotiations. These models have developed at an astonishing pace in the last thirty years. Three decades ago, researchers rightly presented simple spread sheet models established on restricted data bases as the state-of-the art. Fast advancing computer technology and software thereafter quickly enabled the development of comprehensive models which are based on faster software platforms. Today global multi region general or partial equilibrium models covering surprisingly detailed regional and sectoral information have become common fixtures in the analysis of the WTO negotiations.

However, this is certainly not the end of the rope as there is no "one size fits all" model to completely handle WTO issues. Rather, some models are perfectly fitted to one question (e.g., How does trade develop after the WTO round?), but do not contribute much to answering others (e.g., Does this reduce the number of farms in Germany?). Furthermore, the scientific community and other clients, particularly policy makers, are increasingly asking for results on the WTO negotiations which are not only as detailed as possible, but additionally are also consistent over the global, sectoral and farm level. Accordingly, it seems obvious to link models that deliver results consistently disaggregated to various levels, and thereby offset each other’s drawbacks. Manifold examples for this procedure are already available in the literature. In terms of the WTO analyses, these are economic simulation models enriched with all kinds of different sub modules (e.g., tariff modules) or linked to other simulation models (e.g., the LEI's model funnel) to form a combined model system.

Given this background, the goal of our paper is threefold. We first give a brief introduction to a project initiated by the vTI that assesses the impacts of WTO negotiations on the global, national and farm level (Chapter 2). In so doing, it aims to provide consistently disaggregated results by using a global general equilibrium model and a farm group model in conjunction with each other. To explore the use of a model chain from different angles, we also present a literature overview that comprises the combination of macro and micro models (Chapter 3). Here, we concentrate on systems that integrate different models to disaggregate the supply side of the agricultural sector. The literature survey is used to derive an appropriate link for the global general equilibrium model and the farm group model used in our project (Chapter 4). Additionally, we identify the challenges and pitfalls we have to face by combining these models. Finally, we conclude with a short summary (Chapter 5).

2 Overview of the Project

In the Doha Development Agenda (DDA) WTO members are requested to improve market access, eliminate export subsidies and reduce domestic support. The implementation of the WTO negotiations about agricultural trade liberalization will have complex implications for the agricultural market. The analysis of possible consequences of the DDA therefore implies great challenges for modeling. In our project, we are interested analyzing the consequences of the WTO negotiations, not only on the global and sectoral levels, but also on the farm level. Particularly the latter helps us to derive some implications of the WTO negotiation for structural change in agriculture.

Our project is entitled "assessing the impacts of the WTO negotiation on the global, national and farm level." It belongs to a Research Group of the DFG (German Research Community) which focuses on "structural change in agricultural" (SiAg). This Research Group consists of 9 subprojects operating either on the farm level, the intermediate level or policy- and sector level. The objective of this research unit is the integrative economic analysis of structural change driven by technological change, globalization, new societal demands, and a paradigm shift of the agricultural policy. Thereby, already existing theoretical and methodological approaches used in the analysis of the transformation process in the agricultural sector are consolidated, further developed and supplemented. An important feature of this research is the joint application of various quantitative methods, amongst others, partial and general equilibrium models, multi-agent-models, and econometric models. The linkage of those models makes it possible to analyze and evaluate complex policy scenarios.[1]

2.1 Analysis at the Global and Sectoral Level

In our project, the multi region general equilibrium model GTAP (Global Trade Analysis Project) is used in tandem with a farm group model. GTAP provides an elaborate representation of the economy including the linkages between farming, agribusiness, industry and the service sector of the economy. The use of the non-homothetic constant difference of elasticity (CDE) functional form to handle private household preferences, the explicit treatment of international trade and transport margins, and a global banking sector which links global savings and consumption are innovative in GTAP. Trade is represented by bilateral matrices based on the Armington assumption. Further features of the standard model are perfect competition in all markets as well as a profit and utility maximizing behavior of producers and consumers. All policy interventions are represented by price wedges. The framework of the standard GTAP model is well documented in the GTAP book (HERTEL, 1997) and available on the Internet (www.gtap.agecon.purdue.edu). Given this theoretical structure, GTAP is employed in the project to capture price and quantity changes which are calculated taking the global and economy-wide accounting restrictions into consideration.

This standard GTAP model is enriched with a SAS (Statistical Analysis System) module to calculate tariff cuts at the 6-digit tariff line level (BROCKMEIER and PELIKAN, 2008). Additionally, we intend to enlarge the GTAP model with a similar module for domestic support. Up to now domestic support issues are taken less into account in the modeling of the WTO negotiations because VAN TONGEREN et al., (2006) and DIMARANAN et al. (2003) mention that the standard GTAP model is not well-suited to analyze domestic support issues. JENSEN and YU (2005) argue that the modeling issues of domestic support are far more complicated compared to the modeling of market access barriers or export subsidies. The main reason for this is the difference in domestic support programs, which can vary widely from one country to another.

There are only a few examples of modeling domestic support in GTAP in the literature. FRANDSEN et al. (2002) extend the standard GTAP model based on Version 5 of the GTAP database to examine the impact of further decoupling of domestic support in the EU. They model the key institutional features of the CAP (Common Agricultural Policy), e.g., direct payments, budgetary limits, milk and sugar quotas and the effects of inter-regional transfers between EU member states and adjusted the database by adopting recent work of the OECD's PSE. FRANDSEN et al. (2002) show that the GTAP database can be adapted to accommodate EU domestic policies. Furthermore, their analysis demonstrates that domestic support policies have an effect on international trade. But the study has also identified a need to further improve the modeling of domestic support in GTAP.

DIMARANAN et al. (2003) extend the analysis of domestic support. They aim to assess the impact of changes in both the mix and the levels of domestic support in OECD countries on the welfare of farm households in those countries, and on the national welfare of developing countries. For this purpose they construct a special version of the GTAP model and database (Version 5) by adapting recent work of the OECD to make it more appropriate for the analysis of domestic support.

Furthermore, RAE and STRUTT (2003) contribute an analysis to clarify the definition of the amber, blue and green boxes of the domestic support categories in the GTAP database. They provide a mapping from these boxes to the domestic support measures in the GTAP database which takes the discrepancies in the components of the AMS and the PSE into account. In so doing, they consider output subsidies and intermediate input subsidies as an approximation for the amber box and land-based and capital-based payments as an approximation for the blue and green boxes.

JENSEN and YU (2005) model the possible implications of the 2004 Framework of the Doha Round in GTAP. They carefully examine the modeling of domestic support in GTAP taking into account the amber, blue and green box payments. Furthermore, they specify the requirements for a sensitive modeling approach for GTAP and extend the model correspondingly.

WALSH, BROCKMEIER and MATTHEWS (2007) use an extensive domestic support database to calculate the change in applied domestic support rates from a specified cut in bound rates. The analysis also enables the impact on different domestic support boxes to be identified, which can be accurately represented and distinguished at the GTAP aggregation level, and the required reduction in each support category. For this purpose, they extend the GTAP model to incorporate an explicit representation of the market price support element of the AMS.

2.2 Analysis at the Farm Level

After the extension of the GTAP model in the area of domestic support, it is still not possible to identify the impacts of the DDA on the farm level. We therefore link the GTAP model with a sector consistent farm group model. In our project, we choose to use FARMIS (Farm Modelling Information System). FARMIS has been developed at the vTI since 1996, and enables the implications of different policy options on the regional and farm-group level of the agricultural sector to be analyzed. It can be defined as a comparative-static process-analytical mathematical programming model for farm groups which is based on the Farm Accountancy Data Network (FADN) database of Germany or, alternatively, the European Union. Results can be aggregated to sector level using appropriate weighting factors. Thus, FARMIS represents very detailed agricultural activities on the farm level, namely 49 production activities. It is calibrated with positive mathematical programming to the observed base year levels and projected into the future, while the linear part of the objective function maximizes the farm income. The matrix restrictions of the model cover the areas of feeding, intermediate use of young livestock, fertilizer use, labor, and political instruments, for instance direct payments, set-aside and quotas. The FARMIS model has been extended to explicitly include trade of land, milk quotas, premium rights and young animals with the goal of modelling the supply and demand of production factors and the determination of equilibrium prices. Model output includes information on land use, production, different income indicators, and the use of production factors (e.g., mineral and organic fertilizers, energy input, feed use, family labor and hired labor). A detailed description of FARMIS is given in, e.g., OSTERBURG, OFFERMANN and KLEINHANSS (2001) and BERTELSMEIER (2004).

FARMIS will also be extended in the project. Here, the intention is to improve the representation of the factor markets and to endogenously model structural change on the farm level. The latter includes an econometric estimate of the probability that a farm is closing down or being-taken over by a successor, taking into account expected future income as well as individual farm characteristics. This analysis is based on the FADN database and the farm structural survey (FSS). The econometrically estimated succession model will then be linked to the programming model to simultaneously take into account the impact of policy changes on income and farm structure as well as the impact of structural change on the expected income of surviving farms.

Besides the extension of GTAP and FARMIS, the project also aims to develop a consistent interface between the two models. Therefore, it seems to be helpful to conduct a literature survey of studies that link GTAP or macro models with models on the micro level.

3 Literature Survey of Linkages between Different Models

The literature survey gives an overview about already existing model systems. We discuss the aims which are intended to be achieved by using models in tandem. In addition, selected model linkages are introduced whereby a particular focus is given to different types of models (e.g., macro or micro models), aggregation levels, kind of interfaces, and interchanged variables.

3.1 Types of Model Systems

Considering the literature it becomes obvious that it is necessary to distinguish between different kinds of model linkages. On the one hand, there is extensive literature in the field of climate change analysis, where model linkages have a long tradition and are accordingly quite advanced. Here, predominantly CGE models are combined with land use models based for example on GIS (e.g., RONNEBERGER et al. (2006)) or coupled with nitrogen models (e.g., SCHAFER and JACOBY (2003)).[2] This research mostly couples economic models with non-economic models which is only conditionally helpful for our project and thus excluded from the literature survey in this paper.

On the other hand, there are model linkages in the literature connecting economic models. Here, the combination of CGE models and micro simulation models is strongly represented in the literature. The idea behind these various approaches is mainly to substitute the representative consumer by more disaggregated households. In HÉRAULT (2005) a CGE model for South Africa is, for example linked with a micro simulation model. This linkage is based on a sequential approach to build an effective tool that is used to assess the effects of various macroeconomic policies and shocks on differentiated South African households. ARNDT (2006) couples the GTAP model with a standard trade focused CGE model of Mozambique which is based on data from the national household budget survey of Mozambique. In addition, a micro simulation module is developed to assess the implications of trade liberalization on poverty. Also, EMINI et al. (2005) build a CGE with an embedded micro simulation model to analyze the implications of the Doha Development Agenda. Here, special emphasis is given to the role of tax policy on poverty in Cameroon.[3]

In contrast, only a very few papers deal with the coupling of CGE models with economic models that delivers a detailed picture of the production side. In our project we also want to analyze the impacts of the WTO negotiation on the farm level. We are therefore particularly interested in linkages of models that help to disaggregate agricultural production. In the following we therefore discuss model systems particularly established for this purpose, which are comparatively presented in table 1.

KIRSCHKE et al. (1998) present a model linkage that is called hybrid model and consists of a farm module, an aggregation module and a market module. Objective of the project is to analyze the future development in the agricultural policy of the European Union from the view of the newly-formed federal German states. The implications of various policy scenarios on different levels and on different agricultural policy objectives are presented. The fundamental aim of the analysis is the elaboration of a decision basis for the further development of agricultural policy of the European Union (compare table 1).

Since the mid 1990th MANEGOLD et al. (1998) work on the linkage of models. The aim is the construction of a more comprehensive tool for the assessment of EU agricultural policy implications on national, regional, sectoral and farm level. Accordingly, models that operate at different levels are linked in this model chain at the vTI[4]. These are GAPsi (partial equilibrium model), RAUMIS (regional differentiated sector model), BEMO (representative farm model) and TIPI-CAL(synthetic farm model). Further development of the vTI model network implied a replacement of GAPsi by AGMEMOD[5] which is a system of econometrically estimated partial equilibrium models of the member states of the European Union (BERTELSMEIER, KLEINHANSS and OFFERMANN, 2003). AGMEMOD allows making projections and simulations in order to evaluate measures, programs and policies at the European Union level as well as at the Member State level. RAUMIS is a regionalized agricultural and environmental information system, which is a comparative static non-linear positive mathematical programming model. It presents regional adjustments of the agricultural sector on agricultural and environmental policy measures. The vTI modeling network is also enlarged with the models FARMIS and GTAP.

Table 1: Literature Survey of Model Systems

Paper / Project	**vTI-Modelling-Network**	**FAPRI-Ireland**	**Hybrid model**
Author	Manegold et al. (1998), Bertelsmeier et al. (2003)	Binfield et al. (2000)	Kirschke et al. (1998)
Aim	Further development of quantitative models for analyzing the implication of policies. Contributing studies about the quantification of sectoral, regional and farm level implications of agricultural policy reforms	The aim is to provide comprehensive and timely analysis of agricultural policy to a wide range of clients, including policy makers, industry and farmers. The approach therefore needed to be able to provide multi-sectoral projections, whilst being flexible enough to incorporate the intricate policies in place under the CAP	Combining different methodological approaches to a common model framework, to identify implications of the EU agricultural policy on different aggregation levels. To achieve a tool to analyse complex questions - like for instance the implications of the expanding European Union, the ongoing trade liberalisation and the changes in the CAP e.g. decoupling of the direct payments.
Model (Name, Type)			
Global	GTAP (CGE)	FAPRI's world model (PE)	
EU	GAPsi, (PE), AGMEMOD (PE)	FAPRI's EU model (PE)	
National		FAPRI-Ireland model (PE); Interlinkages in the model	Market modul (CGE)
Regional	RAUMIS (regional differentiated sector model, positive mathematical programming)		
Sectoral	FARMIS (mathematical programming model)		
Farm	BEMO (representative farm model), TIPI-CAL(synthetic farm model)	Farm models (LP)	Farm modul (LP) Projection modul - which offers weights to aggregate the results of the model farms on market or sector level
Landscape			
other		Commodity models	
Interface			
Type	Informal linkage - no formal technical linkage between the models. The models still remain independent from each other - each model is constructed as a discrete model. The models are only loosely coupled, but specific results of endogenous variables of one model are transmitted as exogenous variable to the other model. Objective of the model group is the common application (iterative or recursive) of the different models regarding the comparative advantages. Both a top down approach and a bottom up approach is applied.	Price linkage equation (single equation framework) between FAPRI-EU model and FAPRI Ireland model Interlinkages between the commodity models to form overall model, which results are incorporated in the farm models	Prices generated by the market module are delivered to the farm module. If there is a gap between those prices and the expected prices of the model farms, the prices are given back to the market module and the process starts again
Interchanged Results	Calibration of assumptions Information as an input requirement for other models Reciprocal control of results	Transmission of dairy prices from Europe to establish the farm level milk price in Ireland	The market module generates prices and delivers them to the farm module.
Results			
Objective achievement	The model group achieved a very good competence in the field of Common agriculutral policy (1. pillar) consulting	This approach has allowed the incorporation of the specific characteristics of of the Irish dairy sector to be incorparated in the model	The use of a typical farm model allows the modeling of complex transfer policies. Even subsidies and quotas can be implemented directly. The implications of the policies can be precisely identified.
Problems / Requirements	Difficulties in the analysis in the joint use of models due to the permanent required further development of models and the adjustment for the object of investigation.		The feedback of single farm adjustment response over the market only by using restrictive assumptions concerning price effects

Table 1: Literature Survey of Model Systems (continued)

Paper / Project	**"LEI Modelling Funnel"**	**GTAP/DRAM**
Author	van Tongeren (2000)	Helming et al. (2006)
Aim	Description of the models that together constitute the LEI Modelling Funnel	Linking GTAP with DRAM and the Land Use Scanner to have a link between the agricultural sector and the rest of the economy
Model (Name, Type)		
Global	GTAP (CGE)	GTAP (CGE)
EU	CAPMAT (CGE)	
National		
Regional	DRAM (PE)	DRAM (PE)
Sectoral		
Farm		
Landscape		Land Use Scanner (based on GIS)
other		
Interface		
Type	The models are loosely coupled rather than attempting a formal technical linkage between them. Consistency between the models is achieved mainly through passing outcomes from a higher aggregated level as exogenous input to an adjacent model at a more disaggregated level.	GTAP was linked to DRAM, which focus is on product, as well as on region specific production technologies and on the production decision of farmers. In addition both models are linked to the Land Use Scanner to endogenize the agricultural land availability via changes of the asymptote of the land supply curve. The models are linked in such a way that in the projection generation process output of one of them becomes input for the other.
Interchanged Results	The output of one becomes input of another model	The model chain starts from the Land Use Scanner, which calculates the land-use projection being a consequence of expected economic developments and of government policies on the use of space and other scenario assumptions. This projections are fed into GTAP, which assess the consequences of the scenarios for the Netherland as a part of the world economy. The land-use projections from the Land Use Scanner are used to alter the asymptote of the land supply curve in GTAP. The output of the GTAP model includes real product prices and sectoral productivity changes. They are used in DRAM, which generates production volume for a number of crops and animal products as well as among other outputs manure at the regional level.
Results		
Objective achievement		The GTAP-DRAM link has 3 advantages: It makes it possible - to assess implications of the worldwide economic scenarios for the Dutch agricultural sector at the regional level - to examine the economy wide consequences of policies and technological changes present in DRAM and lacking in the GTAP model - it enables the endogenization of prices of output and input in DRAM consistent with global equilibrium conditions The results show that the agricultural development depends greatly on the speed of overall economic development and less on the agricultural policy.
Problems / Requirements	Danger of inconsistencies in data and exogenous assumptions	Since both the GTAP and the DRAM models predict production changes of agricultural sectors, the iterative solving procedure of both models leading to the consistent production results is necessary. The production changes in GTAP and DRAM can differ, because of differences in the cost structure. DRAM takes, e.g., manure policy, different product and region specific production technologies into account, which are not present in GTAP. Tax or subsidy equivalents of these costs will be calculated to fix the sectoral production in the GTAP model on the level obtained by DRAM. This in turn will produce new real product prices and productivity changes, which will be used for DRAM simulations to calculate the new output changes. The iteration process stops when the agricultural changes in DRAM will be sufficiently close in the two consecutive iterations. Difficulties: - different objectives of the models, therefore different structure, definition and specification of variables and units; results could be improved if definition and specification of variables were harmonized - differences in the base situtation; DRAM database available for 1996; GTAP database for 2001; recommendment that both models use the same starting position and to use avarage figures over at hree to five year period -sometimes large differences in cost shares; cost shares have to be harmonized before linking the models

Table 1: Literature Survey of Model Systems (continued)

Paper / Project	GTAP / DRAM	EURURALIS
Author	Kuhlman et al. (2006)	Klijn et al. (2005)
Aim	Aim of this article was to explicity explore the links between a macro-economic model, an agricultural sector model and a land use model to arrive at a consistent model chain and applying it to two contrasting scenarios.	Linking different models to analyze complex policy scenarios on different aggregation levels
Model (Name, Type)		
Global	GTAP (CGE)	LEITAP (CGE), IMAGE (dynamic integrated assessment modelling framework for global change)
EU		
National		
Regional	DRAM (PE)	
Farm		
Landscape	Land Use Scanner (based on GIS)	CLUE (Land use allocation model)
other		
Interface		
Type	Top down approach, trying to avoid all the problems related to representing an aggregate (macro) system from micro-behavior. Only in two instances an iterative feedback mechanismen is included in the system: The agricultural supply equations in GTAP are replaced by DRAM and used the general equilibrium framework to deliver a consistent set of prices for inputs and outputs. The demand equations in DRAM are made consistent with the CGE outcomes. The land availability comes from the spatial land allocation model and a one-step feedback loop to the macro-level is engaged.	Iteration process between GTAP and IMAGE which stops when land-use is the same in both models
Interchanged Results	The output of one becomes input of another model	In GTAP - the exogenous part of the yield is updated in an iterative process with the IMAGE model. The GTAP-output used for the IMAGE.iteration is sectoral production growth rates and a management factor describing the degree of land intensification
Results		
Objective achievement		
Problems / Requirements	Harmonization of databases, because the definition and specification of variables differ between the two models. GTAP has an extended input-output table which registers transactions in money terms, while the agricultural sector model accounts with supply and utilization tables in physical units.	The different models rely on different data sources that are not always consistent and the models can be improved to better include top-down and bottom-up analysis of land use change effects that include important feedbacks

Table 1: Literature Survey of Model Systems (continued)

Paper / Project	**SEAMLESS**	**SCENAR2020**
Author	Barbier et al. (2005), Flichman et al. (2006)	Banse et al. (2008)
Aim	Constructing model linkages to better capture the policy implications on different aggregation levels and to improve the performance of the models. The objective of linking GTAP and CAPRI is to improve the performance of both models, contributing to the analysis of the impact of agricultural policies on the international competitiveness of European agriculture, international trade and production in the rest of the world. Seamless aims at analyzing third country impacts of EU agricultural policies.	To identify the major future trends and driving factors and perspectives and challenges resulting from them for European agriculture and food sectors until the year 2020 on national, regional and landscape level as well as sectoral level
Model (Name, Type)		
Global	GTAP (CGE)	LEITAP (CGE)
EU		ESIM (PE)
National		
Regional	CAPRI (PE)	CAPRI (PE)
Sectoral		
Farm	FSSIM (integrated modelling system developed to assess the economic and ecological impacts of agricultral and environmental policies and technological innovations)	
Landscape		CLUE (Land use allocation model)
other	APES, EXPAMOD, econometric labour model, territorial models, structural change model, developing countries models	
Interface		
Type	CAPRI itself can work independently of the rest of the SEAMLESS-IF. The integration of CAPRI is done using the supply responses obtained through the use of FSSIM for calibrating the supply behavior of CAPRI The agricultural sector within GTAP is replaced by results generated from the CAPRI model. The link based on an iterative procedure. There are only a few basic models, the other specific models and processing tools are used for permitting the linkage between some of the basic models (EXPAMOD between FSSIM and CAPRI)	Both model types have been applied independently from each other without an implementation of a close formal link between both types models
Interchanged Results	CAPRI delivers specific variables (output values) to GTAP and after rebalancing the SAM and calibrating the model GTAP delivers price changes of intermediate inputs to CAPRI	
Results		
Objective achievement	GTAP allows to study the competitiveness of the EU sector relative to a great number of international players on the world market and of the agricultural sector in the EU relative to other economic activities. CAPRI allows to regard the intra-EU competitiveness of regions and how policies are affecting international and intra-EU competitiveness of the agricultural sector	Both models are based on similar assumptions with regard to policy changes and changes in main macro-economic variables. But, both models have been applied independently from each other. Therefore the Scenar2020 results based on an integrated quantitative analysis of the CAP policy option - future projects will focus on formal linking of partial and general equilibrium models.
Problems / Requirements	Aggregation: -linking GTAP and CAPRI requires a mapping of sectors and regions -consistency between the assumptions of the models has to be arrived Variables: Different scales and methods require specific linkage procedures. It is not always possible to make a direct aggregation Results: A potential overlap in results is given. A parallel application of models, would, e.g., produce two sets of results on changes of agricultural output values. These results would not coincide perfectly even if scenario assumptions, data and structural parameters would be made consistent as far as possible Suggestion: A full link of both models	No formal linkage - as a consequence, there remains a certain degree of inconsistency between the outcome of both types of models

The Landbouw Economisch Instituut (LEI) strongly advances the development of model linkages. VAN TONGEREN (2000) uses the metaphor of a "funnel" for the LEI modeling approach, whose design he describes as quite similar to the approach set out in MANEGOLD et al. (1998). The "LEI Modeling Funnel" consists of the GTAP model to capture global issues and a general equilibrium model of the level of the European Union that is called CAPMAT/ECAM and emphasizes the agricultural sector. At the national Dutch level, LEI uses a regionalized partial equilibrium model of the Dutch agriculture (DRAM) to analyze specific regional and activity-related effects of national and EU agricultural policies. DRAM is a non-linear, partial equilibrium, positive mathematical programming model which generates production volume for a number of crops and livestock products as well as manure at the regional level. DRAM focuses on region-specific production technologies and the production decision of farmers. Micro data models are used at the farm level which is based on the Dutch bookkeeping (FADN) data. Technical models are also linked to estimate emissions of the agricultural sector.

In their analysis, HELMING et al. (2006) and KUHLMAN et al. (2006) utilize a linkage of GTAP and the Dutch regionalized agricultural model (DRAM). Both models are also linked to the GIS based land use scanner to endogenize the agricultural land availability via changes of the land supply curve. Thus, the land use scanner enables the generation of spatially disaggregated results.

Parts of the LEI model funnel are involved in the projects EURURALIS, SEAMLESS[6] and SCENAR2020 which also aim to link different models to analyze complex policy scenarios at different aggregation levels. Research in the EURURALIS project is based on an adapted version of GTAP that is called LEITAP. In the first step, LEITAP is linked to an environmental model with mainly national output. This output is thereafter used as input for a more detailed land use model. A special version of the GTAP database and model has been constructed to analyze the agricultural sector by using information from the OECDs Policy Evaluation Model (PEM) on land allocation (KLIJN ET AL. 2005). Additionally, the Integrated Model to Assess the Global Environment (IMAGE), a dynamic integrated assessment modeling framework of the global change, is used to account for the green house gases.

SEAMLESS is engaged in constructing model linkages to better capture the policy implications on different aggregation levels. Particularly important are the implications of the ongoing changes of the CAP for developing countries. SEAMLESS consists of numerous different models and processing tools which are introduced in FLICHMAN ET AL. (2006). The model of SEAMLESS comprises a biophysical model (APES), a farm bio-economic model (FSSIM), an agricultural sector model (CAPRI) and a global general equilibrium model (GTAP). Additionally, an econometric labor model and an econometric model to interpolate results obtained in a sample of regions and farm to the whole EU is involved. These models are supplemented with territorial models, structural change model and developing countries models. For the objective of our project, the linkage between GTAP, CAPRI, FSSIM and the Structural Change Model is of particular interest. Common Agricultural Policy Regionalized Impact Analysis (CAPRI) is the name for an EU-wide quantitative agricultural modeling system. The objective of this system is to assess the effect of CAP policy instruments not only at the EU or Member State level, but at sub-national level (FLICHMAN ET AL. 2006)[7]. The Farm System Simulator (FSSIM) is an integrated modeling system developed to assess the economic and ecological impacts of agricultural and environmental policies and technological innovations (for a detailed description see FLICHMAN ET AL. (2006)).

The purpose of the linkage between GTAP and CAPRI is to derive a model structure that improves the extent to which CAPRI accounts for feedback with other sectors and countries. Simultaneously, the extent to which GTAP accounts for EU agricultural policy and production is enhanced. Such a model structure improves the performance of both models (BARBIER et al. 2005).

BANSE et al. (2007) develop an approach based on the linkage of the economic models LEITAP, CAPRI and ESIM, the ecological-environmental-based model framework IMAGE and a land use allocation model (CLUE-s) under the name Scenar2020. This model system is used to identify the major future trends, driving factors as well as perspectives and challenges resulting for the European agriculture and food sectors until the year 2020 on a national, regional (NUTS 2), landscape and sectoral level. The European Simulation Model (ESIM)[8] is a multi-commodity, multi-regional, comparative-static, net-trade, partial-equilibrium policy model, which allows modeling of the agricultural and policy environment of the EU member states.

Furthermore, Eurostat, the Australian Bureau of Agricultural and Resource Economics (ABARE), the French National Institute for Agricultural Research (INRA), the Food and Agricultural Policy Research Institute of the Iowa State University (FAPRI) and FAPRI-Ireland Partnership, as well as the Organization for Economic Co-operation and Development (OECD) in collaboration with the Food and Agriculture Organization of the United Nations (FAO), are also working with different kind of models. However, their intention is not to primarily aim at the development of a linked model system. Regarding their documentations of model systems it seems as if they are prior interested in the simulation of policy scenarios applying different types of models simultaneously. But the grade of a jointly application of models and especially the form of the linkage is not made transparent.

Comparing the different model linkages, it becomes obvious that most of the economic model systems comprise a global CGE model (GTAP), national CGE models (ORANIGFR, CAP-MAT) or PE models (ESIM, AGMEMOD, FAPRI) as well as models at the regional (DRAM, CAPRI, RAUMIS) or farm level (FSSIM, FARMIS). These frameworks coupling different models pursue similar goals. In general, all model linkages are constructed to answer complex questions and to show the implications of policy changes taking into account specific policies for a single country or region without disregarding the influence of trade liberalization on a global level. A further common objective of most model systems is the development of a modeling tool which delivers differently disaggregated results which are consistent over all aggregation levels.

3.2 Interchanged Results and Type of Linkage

The literature survey reveals that there are rather different ways to link models within a model chain. However, often this procedure is very complex and is mostly not described in detail in the literature. From the survey it is, however, obvious, that model systems (e.g., LEI model funnel, vTI model network, EURURALIS) mainly consist of an informal linkage between models at different levels (see also Table 1). This means that the models are loosely coupled and are not combined with the help of a formal technical linkage. Consistency between models is primarily achieved by passing outcomes of a model with a higher (lower) level of aggregation as exogenous input to an adjacent model at a lower (higher) aggregation level. Thereby, top-down as well as bottom-up approaches are presented in the literature to pass results from one model to another model of the system.

In most cases, the model at a higher aggregation level delivers endogenously calculated prices, whereas the lower level aggregation model is mainly responsible for the provision of endogenously calculated supply quantities. Due to different aggregation levels of the combined models, a mapping of sectors and regions, as well as a mechanism for ensuring consistency between results is required. If variables are defined on different scales (e.g., export prices defined as vectors in single country and as matrices in multi country models), an additional weighting scheme might be needed (BARBIER ET AL. 2005). A specific problem of the transfer of results arises when two adjacent models within a network operate on different units, e.g., value and quantity terms. According to FLICHMAN ET AL. (2006) it might then be necessary to develop intermediate models that enable the transformation of one unit to the other. This kind of interface will be used in the SEAMLESS project. Here, the combined models are different with respect to the scales and the methods used (e.g., simulation models, econometrically based models). A few basic models are combined with the help of other, more specific, models and processing tools which are only used to permit the linkage between the basic models.

The transfer of results is not always restricted to one variable. Some model chains even replace the results in one part of a model with the results of another model. GTAP and CAPRI are, for example, linked through the replacement of the agricultural sector within GTAP by results generated from the CAPRI model. This procedure is motivated by the better performance of CAPRI with regard to the EU agricultural policies (e.g., premiums or quotas) and the more disaggregated representation of the agricultural sector.

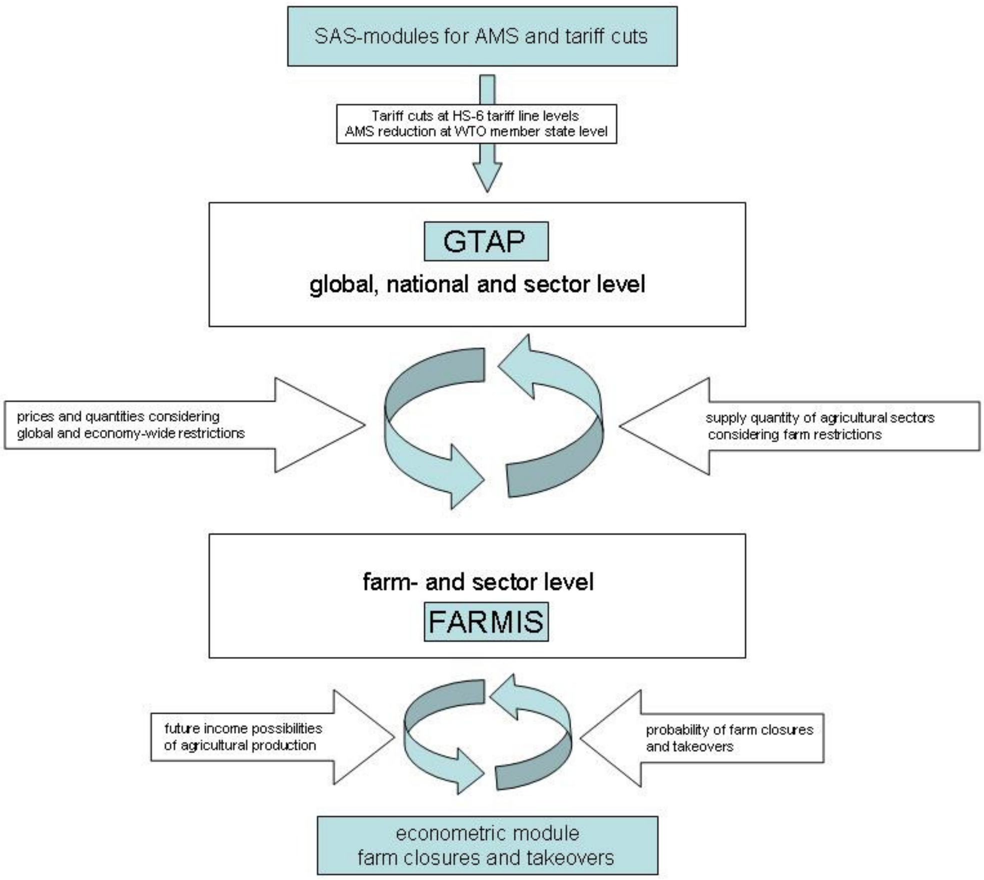
In some cases the results obtained in one model are used as input by another, but without repercussions. Thus, there is no feedback between the models. Other model systems use a specific link that is based on an iterative procedure. This is particularly important for the consistency of the results, if one variable occurs endogenously or exogenously in different models. For example, CAPRI delivers specific variables to GTAP in each iteration. Thereafter, the data base of GTAP is rebalanced and calibrated to the new SAM. With the help of this procedure, GTAP delivers price changes of intermediate inputs to CAPRI. This allows a recalculation of input cost for CAPRI production activities that are used in the next simulation run. The iteration process stops when the output value changes of CAPRI and price changes of GTAP are marginal. A similar procedure is used in HELMIG et al. (2006) and KUHLMAN et al. (2006) for the linkage between GTAP and DRAM.

A potential overlap in results generated by both models might however cause problems when the iterative procedure does not produce converging results. Due to differing model structures this might be the case even if scenario assumptions, data, and structural parameters are made as consistent as possible. To avoid conflicting results and the development of sophisticated strategies to interpret and communicate those differences, FLICHMAN et al. (2006) suggest a fixed linkage between adjacent models. However, so far, almost none of the models undergo changes which prevent them from running without the other models of the model system, e.g., examples of fixed interfaces between the models are rare in the literature.

4 Lessons to be drawn for our Project

As mentioned above, we aim to link the GTAP and the FARMIS models in our project. Based on the experience from the literature overview it seems to be appropriate to develop an informal linkage between the two models. In so doing, we plan to follow the procedure displayed in Figure 1. In the first step, the extended GTAP model is utilized to calculate the implications of the WTO negotiations. Tariff, as well as AMS, cuts are calculated with the help of sub modules taking the most detailed available tariff and protection information into account. Solving the GTAP model provides consistent prices and quantities on a global, national and sectoral level which take the global and economy wide restrictions into consideration. The resulting prices of GTAP are passed on to FARMIS, where a first run delivers the future income possibilities of agricultural production. This information is then incorporated in the econometric module which calculated the probabilities of the closing down and taking over of farms. The last two steps are repeated until results converge. Thereby, FARMIS provides agricultural supply quantities while taking farm restrictions into account. The production quantities are transferred to GTAP where a further run produces a new price-quantity framework that not only takes global and economy-wide, but also farm restrictions into account. The procedure needs to be repeated until the price and quantity changes of GTAP and FARMIS are marginal.

Figure 1: GTAP / FARMIS Interface



For the development of this linkage between GTAP and FARMIS, it seems to be important to carefully consider the following questions:

- How can baseline and policy scenarios be consistently defined for GTAP and FARMIS?
- What kind of process is needed to transform the price and value changes in GTAP into the price changes in absolute terms in FARMIS?
- How can the higher aggregated results of GTAP be mapped to the disaggregated sectors of FARMIS?

5 Summary

The analysis of agricultural policy often deals with questions which not only concern the global, but also the national or farm level of the agricultural sector. A model that is fully consistent and operational at different levels of aggregation is not available and most likely also not feasible. Thus, combinations of differently disaggregated models have become a common tool in agricultural policy analysis. These model systems mainly consist of loosely coupled models, while fixed technical linkages are the exception. Thus, results are primarily passed from one model to the adjacent model in the chain, while consistency is achieved through the application of an iterative procedure. Mostly, a global CGE model, a national CGE or PE model as well as models at the regional or farm level are used in tandem, to deliver consistently disaggregated results for the analyzed issue in question. In so doing, the model chains are able to take detailed agricultural policies of a single country or region into account without disregarding global and economy-wide restrictions.

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1 http://www.agrar.hu-berlin.de/struktur-en/institute-en/wisola-en/fowisola-en/siag-en

2 RONNEBERGER et al. (2006) link an extended version of the GTAP model (GTAP-EFL) to a land use model called Kleines Land Use Model (KLUM) to consistently assess the integrated impacts of climate change on

global cropland allocation and its implication for economic development. They capture the biophysical aspects of land as well as the spatial explicitness of land-use decision. In contrast, SCHAFER and JACOBY (2003) used the MIT Emission Prediction and Policy Analysis (EPPA) model. This CGE model is build on the GTAP4-E database and in the first step combined with a linear programming model called MARKAL. MARKAL latter is an engineering-process type model of the transport sector. A model of modal splits in transportation is additionally used to connect the aggregate transport sector of the EPPA model to the technology detail of MARKAL with the intention to study the imbedding of specific transport technologies within a multi-sector, multi-region evaluation on greenhouse gases.

3 More examples of combinations of CGE models and micro economic models can be found in HERTEL and WINTERS (2006).

4) The Johann Heinrich von Thünen Institute (vTI) is the Federal Research Institute for Rural Areas, Forestry and Fisheries, which was founded on the 1th January 2008. This institute is partly a successor of the Federal Agricultural Research Centre (FAL), see for more information: http://www.vti.bund.de

5) See for more information: http://www.tnet.teagasc.ie/agmemod/the models2020.htm

6 System for Environmental and Agricultural Modelling; Linking European Science and Society

7) For more specific information concerning CAPRI, see http://www.agp.uni-bonn.de/agpo/rsch/capri/capri_e.htm

8) For more information on ESIM , see http://www.ers.usda.gov/publications/tb1865/TB1865b.PDF