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Trade, Agricultural Policies and Structural Changes in India's Agrifood System; Implications for National and Global Markets

Collaborative Project

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Table of contents

General part	9
<i>Objective within the project</i>	9
<i>Executive summary</i>	9
<i>Scientific and societal relevance</i>	13
Specific part	15
1 Introduction	15
2 The MAGNET model	16
2.1 <i>Introduction</i>	16
2.2 <i>The GTAP database</i>	17
2.3 <i>The GTAP model</i>	18
2.3.1 Introduction	18
2.3.2 Regional household	18
2.3.3 Imports and exports	18
2.3.4 Firms and factor markets	19
2.3.5 Investment	20
2.3.6 Taxes and subsidies	20
2.3.7 Conclusion	20
2.4 <i>Modified GTAP</i>	20
2.5 <i>Flexible production structure</i>	21
2.6 <i>Dynamic consumption</i>	22
2.7 <i>Labor mobility between agricultural and non-agriculture</i>	22
2.8 <i>Land supply</i>	23
2.8.1 The land supply curve	23
2.8.2 Allocation of agricultural land with a nested CET function	24
2.9 <i>Biofuel directive</i>	26
2.10 <i>Conclusion</i>	26
3 Data adjustment	27
3.1 <i>Introduction</i>	27
3.2 <i>Aggregation level</i>	27
3.2.1 Introduction	27
3.2.2 General method to change aggregation	27
3.2.3 Sector aggregation	28
3.2.4 Regional aggregation	31
3.2.5 Conclusion	31

3.3	<i>The SAM of India</i>	32
3.3.1	Introduction	32
3.3.2	Basic principles	32
3.3.3	International trade	32
3.3.4	Production, consumption and investment	33
3.3.5	Removing inconsistencies	33
3.3.6	Conclusion	34
3.4	<i>Income and price elasticities of consumption</i>	34
3.5	<i>Conclusion</i>	35
4	Dynamic international investment	36
4.1	<i>Introduction</i>	36
4.2	<i>International capital and capital income accounting</i>	36
4.3	<i>Initialization of international capital accounts</i>	38
4.4	<i>International capital allocation theory</i>	38
4.4.1	Calculation of wealth change of regional household	38
4.4.2	Choice between domestic and international investment	39
4.4.3	Investment of the international trust	40
4.4.4	Capital stock and investment	40
4.5	<i>Depreciation adjustment</i>	41
4.6	<i>Determining model parameters and initial values</i>	42
4.7	<i>Empirical foundation and theoretical properties of the dynamic model</i>	42
4.8	<i>Conclusion</i>	42
5	Biofuels and agricultural production	45
5.1	<i>Introduction</i>	45
5.2	<i>Creating new sectors</i>	45
5.2.1	Introduction	45
5.2.2	Splitting the feed and fertilizer sector	46
5.2.3	Splitting molasses from the sugar sector	46
5.2.4	Splitting a crude vegetable oil and oilcake sector	47
5.2.5	Creating biofuel sectors	47
5.2.6	Conclusion	49
5.3	<i>Production structure</i>	49
5.3.1	Introduction	49
5.3.2	Standard production structure	50
5.3.3	Petroleum sector	50
5.3.4	Biogasoline and biodiesel sector	51
5.3.5	Crop sectors	51
5.3.6	Animal sectors	52

5.3.7	Animal feed sector	52
5.3.8	Conclusion	52
5.4	<i>Conclusion</i>	52
6	Trade agreements and international trade	54
6.1	<i>Introduction</i>	54
6.2	<i>Increased flexibility in Armington import elasticities</i>	54
6.3	<i>Use of 6 digit tariff data in an aggregated model</i>	55
6.4	<i>Conclusion</i>	56
7	Baseline design	57
7.1	<i>Introduction</i>	57
7.2	<i>The exogenous projections</i>	57
7.2.1	USDA projections of population and GDP	57
7.2.2	FAO/PBL land productivity projections	58
7.3	<i>Technological change</i>	58
7.4	<i>Dynamic consumption elasticities</i>	59
7.5	<i>Conclusion</i>	60
8	Conclusion	61
	References	62

General part

Objective within the project

The international part of the baseline simulations and scenarios is accomplished through the model MAGNET, till January 2011 called LEITAP. This model has been adapted in such a way that it is better focused on India, has incorporated international capital dynamics, has an opportunity to adjust tariffs based on 6 digit level tariff data, has a structure that is better adapted for agricultural analyses by modelling explicitly intensification of crop and animal sectors, and has included first generation biofuels and sectors that are needed to generate sound results. The model aggregation of MAGNET is made as consistent as possible with the aggregation used in the national CGE model as discussed in TAPSIM deliverable 6.2. Price and income elasticities of consumption are adapted to information generated by TAPSIM deliverable 5.1. A baseline is designed of which the results are discussed in TAPSIM deliverable 7.1 and that is used as a reference scenario for analysing different scenarios in deliverable 7.2.

Executive summary

The purpose of the project TAPSIM is to provide quantitative and qualitative assessments for India of future developments in supply, demand and trade for the main agricultural commodities and to evaluate trade, agricultural and rural policies as well as the consequences of structural changes in India. Based on a partial analysis in Deliverable 5.1 projections for supply and demand are made, while in Deliverable 6.2 a national general equilibrium model is used to analyse the effects of agricultural and rural policies in India. For the interrelationship between Indian and global developments and the investigation of the effect of trade policies the global general equilibrium model MAGNET is used. In order to make the model suitable for this type of analysis a number of new modules for the model have been developed, while parameters and aggregation of the model have been adjusted towards the ones used in the other work packages of TAPSIM.

This report discusses the main features of MAGNET (chapter 2), the improvements made in MAGNET in the context of TAPSIM (chapters 3 till 6), and the design of the baseline that is used in the deliverables on scenarios (chapter 7).

First, on the general principle of MAGNET, which stands for Modular Applied General Equilibrium Tool. The MAGNET model uses the well-known GTAP database and model as its starting point. The basic idea of the system is its modular character. Each user can build his own database and model based on the GTAP model and database by including modules with program code and databases. In this manner the GTAP database can be enriched with extra sectors, regions, or production factors, specific country information, information from international databases like FAO and World Bank, and with adjustments designed by specialists. Each adjustment and addition is a separate module, and these modules can be called by a software interface called Dynamic Steering System (DSS) that has been developed specifically for this purpose at LEI. The choices made by a user for a project are stored in a so-called answer file that enable to document and replicate the choices made by the user and provide also the possibility to do the same adjustments for a new release of the GTAP database. The basic philosophy of the system is that all procedures are coded in the

programming language, and that all procedures start with the data as supplied by the data supplier, making the whole system very transparent and providing an easy manner to replicate procedures for later user. This implies that everything that has been developed for TAPSIM can be used in future projects as well.

The most recent GTAP database describes the global economy in millions of dollars for 2007. The GTAP database is released at three year intervals, the most recent ones are for 1998, 2001, 2004 and 2007 where more recent releases have more differentiation in regions and where sometimes also the number of sectors changes. The global economy in the GTAP version 8 database for 2007 has been divided in 129 regions, 5 production factors and 57 sectors of which 12 primary agricultural sectors, forestry and 8 food processing sectors. Each sector in the GTAP database produces one commodity by using production factors and intermediate inputs. Total value added generated in a sector is allocated to the production factors land, skilled and unskilled labour, capital and natural resources, and a small part is transferred directly as indirect taxes to government. A so-called input-output table describes which sectors use which commodities and production factor as inputs. In order to be able to run the model smoothly the database must be aggregated, where the aggregation level is based on what is needed for the project.

The GTAP model simulates the global economy based on bilateral international trade flows, input-output relationships, and functions that describe the behaviour of firms, consumers and what is called a regional household. The regional household distributes all income generated in a region over private consumption, government consumption and savings according to more or less fixed shares. Private consumption is distributed over demand for different commodities based on a Constant Difference of Elasticity (CDE) consumption function that allows for different income elasticities for different commodities. Government consumption is distributed over different commodities according to fixed shares. Savings are transferred to a fictive bank that uses it for investment in the world.

The GTAP model allows for bilateral trade by using a so-called Armington function. For each commodity a choice is made between buying from domestic suppliers or importers based on relative prices, and for imported commodities a choice is made for the region where it comes from also based on relative prices. In this manner exports for a sector of a region depend on the import decisions of the importing regions and so on their relative price.

Firms produce output by using production factors labour, capital, land and natural resources, and intermediate inputs bought from other sectors. In GTAP the quantity of intermediate input needed per unit of output is fixed, while for production factors substitution is possible between capital, labour and the other production factors. For labour and capital the increase in price is the same for all sectors in a region, while for land and natural resources there are interdependent sector specific prices.

Investment depends on savings, where either the growth of net investment in all regions is the same, or the expected rate of return on investments is equalized over regions. The model assumes that all taxes are ad valorem, implying that the tax as percentage of the total value remains the same. In this manner the GTAP model provides a consistent and complete model of the global economy and its interactions, but in a very rough manner. In MAGNET everything can be replaced by more sophisticated modules of which we describe five examples that are relevant for TAPSIM.

First, if an economy is growing not all sectors have the same speed of technological change, and technological change may be saving for some inputs but not for others. For this reason a sophisticated method to distribute regional technological change over different sectors and inputs has been developed. Second, in GTAP a very simple production structure is available. In MAGNET a completely flexible structure of substitution between different inputs has been designed, although it remains based on the CES production function. Third, for long term projections the income elasticity of consumption changes when welfare in a country

increases. For this reason a calibration procedure has been developed that adjusts the parameters in the consumption function of GTAP to target values that may increase or decrease over time. Fourth, labour mobility in GTAP is perfect, while it is known that the agricultural sector adjusts much slower than would happen if this assumption was correct. Therefore a dynamic system of imperfect labour mobility has been implemented. Fifth, land supply is exogenous in GTAP, while it is known that at higher prices more land is taken into use. For this reason a land supply curve has been introduced that describes the relationship between the land rent and the supply of land. For India this is less relevant than for a number of regions in the rest of the world, but it is relevant if more land is needed in the rest of the world in order to feed the Indians. Finally, to model biofuel policies that focus on blending requirements for the petroleum sector a module for a biofuels directive has been introduced that forces the petroleum sector to blend the fossil fuel with biofuels.

In the context of the TAPSIM projects some important modules with adjustments in the MAGNET database and model have been made. First, an aggregation that is suitable for TAPSIM has been designed. The sector aggregation has been adjusted as much as possible to the one used by the national CGE of India as described in Deliverable 6.2. With respect to the regional aggregation, the EU27 has been aggregated into one region to keep the model manageable and to make it easier to implement EU-wide import tariff changes. In order to be able to adjust aggregation in a controllable manner, a systematic way of creating and adjusting the database has been developed.

When the project started, the GTAP database was based on the 1993/4 input-output table of India (Chadha and Pratap, 2006). This seemed not very relevant for an up to date study of India. Furthermore, it seemed useful to increase consistency between the Indian social accounting matrix for the national and international model as much as possible. Therefore, a procedure has been developed that adjusts the social accounting matrix (SAM) for India in the international model towards the one in the national CGE. Because the sector aggregation in the two databases is not inconsistent, and for example taxes are handled in a different way, a common aggregation has been defined at which the two social accounting matrices can be compared. To synchronize, the numéraire has been adjusted in such a manner that GDP of the two SAM's is the same at the common aggregation level. All elements of the SAM's are defined as fraction of GDP in order to make the two SAMs at the common aggregation level consistent. With respect to exports and imports of India the receiving or supplying regions can be adjusted to make the total imports and exports of India in the international model consistent with the Indian SAM. This is a general adjustment procedure that can be used for all adjustments in the database where trade flows change.

At the end of 2011 a new release of the GTAP database became available having an update for India based on the 2003/4 input-output table of India (Chadha and Pratap, 2012). This makes the adjustment procedure less important, while on the other hand the procedure by definition disturbs the worldwide database. Therefore, although the procedure is not used in the current project, it is available for other projects that have to solve the same problem and it has been a starting point for the development of a library of adjustment procedures. For this reason, the description of the procedures is still discussed in this deliverable (section 3.3).

Finally, a procedure has been developed to use income and price elasticities from national sources in the MAGNET model, either by shifting the function that generates the income elasticities for all regions of the world, or by just fixing the values of the income and price elasticities.

With respect to the model dynamic international investment, biofuels and the possibility to calculate tariff changes based on 6 digit tariff data have been introduced. First, because the Indian economy is in a very dynamic phase, the standard closure of the static GTAP model is not suitable, especially not for long term simulations. Therefore, capital imports and exports and its related income flows have been modelled explicitly. The module uses the international

capital and capital income accounting system that is borrowed from the dynamic GTAP model called GDYN. The basic idea is that savings and part of currently invested funds are first allocated to domestic firms or an international investment trust based on differences in rate of return. Then the international investment trust distributes its funds over different regions of the world, also based on relative rates of return. This implies that without disturbances there is a long term tendency towards equality of rates of return.

Second, biofuels may influence the world economy and therefore India a lot, while also India has very high targets for biofuels that are based on the idea that molasses will be used as the main input. In order to calculate the effects of these policies not only biofuel sectors had to be introduced, but also sectors that are crucial to understand the dynamics of biofuels. For example, byproducts of ethanol and biodiesel can be used as animal feed, while molasses that can be used for biofuel production is also used for animal feed. This required splitting out an animal feeding sector, and splitting out molasses from sugar. Because biodiesel is made of vegetable oil and vegetable oil is in a large sector including a lot of refining of vegetable oil, the vegetable oil sector had to be split in a crude vegetable oil sector and a refined vegetable oil sector, while oilcake as a byproduct of vegetable oil had to be considered explicitly. Finally, because intensification through increased fertilizer use is an important way to increase land productivity, both for food and for fuel, splitting out a fertilizer sector was essential, too.

Third, trade is an important focus of TAPSIM. There is one issue that was relevant when TAPSIM started but is not used anymore in the project although it remains relevant for the future, and another issue that was essential for running the trade scenarios in TAPSIM. With respect to the first issue the following. In 2001 that trade for some, especially agricultural, commodities is almost absent. In the standard model, with relatively low import elasticities, imports and exports will never become important. For that reason dynamic import elasticities have been introduced. With the 2001 database that was used at the start of the project, the effect of this approach was large, but it would require more information on comparative advantages. With the current 2007 database there is more Indian trade in the database with as a consequence that the effect of this model innovation is much smaller, while the disadvantage of using the module remains. Therefore, also this module is a technical innovation that is not used in the current simulations but is available for future use, probably requiring some further development.

With respect to the second issue the following. The analysis of trade agreements in MAGNET was based on changes in bound tariffs at 6 digit level that were applied on applied tariffs at the highly aggregated MAGNET commodities. This seemed not very useful for the analysis of trade in TAPSIM. For this reason, a method has been developed to calculate shocks in MAGNET based on changes of 6 digit bound or applied tariffs depending on the trade agreement at hand, and a method to aggregate these changes. A database with these tariffs has been added to the MAGNET database.

One of the purposes of TAPSIM is to provide projections of supply and demand till 2030 and to analyse the effects of different policies or national and international developments. For this a baseline is required, and for MAGNET this must be an international baseline. The design of this baseline is discussed in chapter 7. Basically, the baseline uses projections of population and GDP for all regions of the world from the USDA, basically because USDA uses information from international sources and regularly updates this information on a very detailed regional aggregation. For India the projections of GDP have been made consistent with those used in the national CGE model for Indian, i.e. 8% per year. Labour supply projections for India are also based on the assumptions used in the Indian CGE model. Land productivity increases are a combination of FAO projections and developments of labour productivity in the baseline.

In summary, in TAPSIM a lot of additions have been made to the MAGNET model that can also be used outside TAPSIM. The model and baseline developed in this report are the tools for the baseline and scenario analysis in Deliverables 7.1 and 7.2.

Scientific and societal relevance

The improvement of the model is a scientific challenge. For a general equilibrium model like MAGNET it is difficult to investigate countries without much trade that may increase their trade in the future significantly. Also international capital flows are not in the standard model, and are potentially very important for the development of India. When these procedures are in the model, they improve all analyses for MAGNET with a long-term character, and also reduce the risk that the model doesn't solve because of inconsistencies in the database and the projections in a long term scenario. Finally, India specific data have to be updated to the most recent available information. The development of procedures for updating input-output tables of a specific country without disturbing the rest of the model has a general applicability, both for projects in the future and for projects related with other countries.

Because one of the scenarios in TAPSIM is about biofuels, the modelling system has been developed to include first generation biofuels in a general way that can be easily extended with other bio-based commodities like second generation biofuels or bio-chemicals. The methods for adding sectors are developed in a general and flexible manner. Also the design of the production structure is designed in such a manner that it can easily be extended. In this way the development of MAGNET for TAPSIM not only helps to improve the modelling of India in an international context, but also helps to ease further developments in MAGNET. The philosophy used can potentially also be implemented in other CGE models.

A model like MAGNET is useful to explore the possible futures of a country like India. It takes into account the international interdependencies. A model like this should not be taken too literally, because it works with relatively aggregated data and general equations that hold for the whole world. Nevertheless, such a model is extremely relevant to help thinking in a consistent way about driving forces and policy alternatives for the Indian economy in relationship with the rest of the world, and especially Europe.

Specific part

1 Introduction

The purpose of the project TAPSIM is to provide quantitative and qualitative assessments for India of future developments in supply, demand and trade for the main agricultural commodities and to evaluate trade, agricultural and rural policies as well as the consequences of structural changes in India. Based on a partial analysis in Deliverable 5.1 projections for supply and demand are made, while in Deliverable 6.2 a national general equilibrium model is used to analyse the effects of agricultural and rural policies in India. For the interrelationship between Indian and global developments and the investigation of the effect of trade policies the global general equilibrium model MAGNET is used. In order to make the model suitable for this type of analysis a number of new modules for the model have been developed, while parameters and aggregation of the model have been adjusted towards the ones used in the other work packages of TAPSIM.

This report discusses first the main features of MAGNET, a model tool derived from GTAP (chapter 2). After shortly discussing the general philosophy of MAGNET, the structure of the GTAP data base and model is discussed, after which a number of modules is discussed that is added in MAGNET to the GTAP core model. In chapter 3 adjustments of the database for TAPSIM are discussed, including the aggregation level, after which three chapters go into three important improvements of the model. First international capital dynamics is added to the model (chapter 4), then biofuels, animal feed and fertilizer are added as sectors to the model (chapter 5), and finally the possibility to have a more flexible trade structure and to introduce international trade agreements based on 6 digit tariff data are discussed (chapter 6). Finally, the design of the baseline is discussed that forms the core of the analyses in deliverables 7.1 and 7.2 (chapter 7).

2 The MAGNET model

2.1 Introduction

The world economy is interlinked. If something happens in one country this may influence the rest of the world, and a country like India depends on what happens with the rest of the world. Computable General Equilibrium (CGE) models are meant to show these interrelationships. The GTAP model is one of the most well-known models of this type, especially because it is related with a consistent international database for CGE models that is the foundation of most global CGE models. The Global Trade Analysis Project (GTAP) is a global network of researchers and policy makers conducting quantitative analysis of international policy issues, and has the GTAP database as one of its main outputs.

At LEI MAGNET (Modular Applied General Equilibrium Tool) has been developed that uses the GTAP model and database as a starting point. The basic idea of the system is its modular character. Each user can build his own database and model based on the GTAP model and database by including modules with program code and databases. In this manner the GTAP database can be enriched with extra sectors, regions, or production factors, specific country information, information from international databases like FAO and World Bank and with adjustments designed by specialists. Each adjustment and addition is a separate module, and these modules can be called by a software interface called Dynamic Steering System (DSS) that has been developed specifically for this purpose at LEI. The choices made by a user for a project are stored in a so-called answer file that enable to document and replicate the choices by the user and provide also the possibility to do the same adjustments for a new release of the GTAP database. The basic philosophy of the system is that all procedures are coded in the programming language, and that all procedures start with the data as supplied by the data supplier, making that everything can be traced and replicated.

The same principle of the database is also used by the aggregation of the database and the generation of data for scenario's. Everything is modular and stored by the user, and should be as independent on the aggregation chosen by the user as is possible. Finally, the model code itself is organized in a modular fashion, where each module is stored in separate files, where each module can be included by the user through the DSS interface. In this manner, a library of modules can be developed, where a user can decide which module is most suitable for the purpose of the analysis, and where a user can also develop some additional modules for the specific purpose of a project. A specific software interface, called GTREE, has been developed that shows the model code in a structured manner, where you can see the separate modules, and where the different steps in the model code are structured according to hierarchical tree structure. The program GTREE generates the code for the programming language automatically.

One of the challenges in analyzing results is that you like to present results in many cases at a higher aggregation level than the model is running, and that you can compare different scenarios in an easy manner. For this purpose a presentation tool has been developed, called GEMSE_Analyst, that aggregates model outcomes in a systematic manner, and has a lot of features to show results in different formats, like as a percentage of a reference scenario, in percentage or absolute changes, in levels, etc.

In summary, the MAGNET modeling system provides a systematic way to process data, organize model code and analyze results, where the GTAP database and GTAP model are the starting point. In this chapter we will discuss first the GTAP model and database, and then

discuss some modules that are relevant for TAPSIM. The modules that have been developed for TAPSIM are discussed in separate chapters of this report.

2.2 The GTAP database

The most recent GTAP database describes the global economy in millions of dollars for 2007. The GTAP database is released at three year intervals, the most recent ones are for 1998, 2001, 2004 and 2007 where more recent releases have more differentiation in regions and where sometimes also the number of sectors changes. The global economy in the GTAP version 8 database for 2007 has been divided in 129 regions, 5 production factors and 57 sectors of which 12 primary agricultural sectors, forestry and 8 food processing sectors. Each sector in the GTAP database produces one commodity by using production factors and intermediate inputs. Total value added generated in a sector is allocated to the production factors land, skilled and unskilled labour, capital and natural resources, and a small part is transferred directly as indirect taxes to government. A so-called input-output table describes which sectors use which commodities and production factor as inputs.

National income in GTAP, i.e. the sum of all value added generated in the different sectors, is earned by one regional household. This regional household distributes this income over private consumption, government expenditures and savings, where the sum of all savings in the world equals investment in the world. Consumption and government expenditures are distributed over expenditures for different commodities, where a differentiation is made between imported and domestically produced commodities.

The international interdependence in the GTAP database is through bilateral trade. The GTAP database describes bilateral trade flows of all commodities. A lot of effort is made to make the international trade database consistent. It is not obvious that the Dutch statistical office reports the same export flow to India as the Indian statistical office reports as imports from the Netherlands. Creating a reliable and consistent database for world trade flows is therefore not an easy task.

In order to transport commodities from one region to another, transport and other handling costs are involved. These transport cost for shipping commodities between India and the Netherlands equal the difference between the import value for India and the export value by the Netherlands (corrected for inconsistencies in prices). The production of these transport commodities is allocated to the countries that supply the transport services.

The GTAP database gives a lot of attention to taxes and subsidies. For this purpose it differentiates between values at market prices and values at agent or world prices. For example, an import tariff on wheat in India is the difference between the import value of wheat at world prices and the import value at market prices. In this manner export tariffs, taxes on the use of production factors or intermediate inputs (differentiated between imported and domestically produced commodities), export subsidies, taxes on consumption, taxes on output and taxes on income are distinguished. Subsidies in this system are just negative taxes. This detailed accounting system in the GTAP database allows for a very sophisticated analysis for the effect of changes in subsidies and taxes.

The GTAP consortium has a lot of other data available that are made consistent with the GTAP database; these are issued at irregular intervals. For example, energy volumes are delivered as well as CO₂ emissions, split into the same demand categories as in the GTAP database. A GTAP land use database is available that registers land cover, land use per crop sector, and the volume of production for these sectors. A forestry database shows the areas of forest and its related carbon stock per agro-ecological zone, management intensity and age. There is also a database on non-CO₂ greenhouse gas emissions available. In summary, the GTAP consortium delivers a lot of relevant information for global analyses.

In MAGNET the GTAP database is used as a starting point. Additional information, for example from FAO, the World Bank, and International Energy Agency. While the additional database delivered by GTAP are processed automatically into an integrated MAGNET database. Additional information like cost structures of specific sectors can also be easily processed into the MAGNET database.

In summary, the GTAP database offers a consistent description of the global world economy with a lot of attention to taxes and subsidies. The GTAP consortium offers also a lot of related databases that can automatically be processed into the MAGNET database. Also information from other databases and sources is used and can be processed into the MAGNET database.

2.3 The GTAP model

2.3.1 Introduction

In MAGNET the GTAP code forms the starting point of the other modules and is kept in its original state as much as possible. In order to make the code easier to read, the code has been reorganized according to make it easier to read. For example, all parts of the code on firms have been put into one chapter on firms, and the same for trade, households, etc. This section discusses the most important elements of the standard GTAP model.

2.3.2 Regional household

The regional household collects all income and distributes income over private consumption, savings and government expenditures. It uses a very simple, Cobb Douglass type of function for this. Savings are supplied to the banking sector and will be discussed later. Government consumption is distributed over different sectors with a simple Cobb Douglass type of demand function. Only private consumption is distributed over different sectors using a more complicated function. GTAP uses the Constant Difference of Elasticity (CDE) consumption function. This function has the property that it allows for different income elasticities, in contrast with CES or Cobb Douglass consumption functions where it is always assumed that a one per cent increase in income generates a one per cent increase in demand for all commodities if all relative prices remain the same. This property for non-homotheticness is important especially if there are experiments that increase income. The CDE consumption function has two parameters, one that is normally calibrated to determine the own price elasticities of consumption, and one that is calibrated to determine the income elasticities of consumption. The disadvantage of this consumption function is that the cross price elasticities of consumption cannot be calibrated independently of the own price and income elasticities, and are normally around zero. Another disadvantage is that the income elasticities don't change when income increases.

2.3.3 Imports and exports

Imports in GTAP are determined by a two level Armington function applied for each expenditure category, so intermediate inputs for firms, private consumption, investment and government consumption. An Armington function is like a CES function, but then applied to imports and domestic commodities instead of inputs of production. For each agent that demands a commodity, first the decision is made either to import the commodity or to buy it from domestic producer. When this decision is made, the choice is made from which region to import the imported commodities. All the potential supplying regions are in one function with the same elasticity of substitution.

The line of argument behind the Armington import demand function is that imported commodities are heterogeneous at the aggregation level used by GTAP. For example, you can not perfectly substitute fruits imported from southern countries that produce oranges with fruits imported from northern countries that produce apples. For this reason, the users have a preference for a mix of the commodities, and therefore the utility of an extra unit of imports from one country decreases when more is imported from that country. This principle is included in the Armington function.

The Armington function has the advantage that it allows for bilateral trade. Exports of countries are completely determined by the import decisions of the importing countries, given the price of the commodities in the different regions of the world.

Trade requires transport. This implies that the price an exporting country gets is lower than what the importing country has to pay. The difference is paid to the transport sectors in GTAP. The payments for international transports are distributed over supplying countries where regions with rising relative transport supply prices get a smaller transport share according to a Cobb Douglas demand function for international transport services. When relative prices of supply of international transport services remain the same, the supply of transport services increases with the same percentage in all regions.

2.3.4 Firms and factor markets

Sectors are called firms in GTAP. Firms in GTAP sell one commodity with the same name as the sector. Because of the substitution possibilities in the consumption function, domestic commodity demand has a negative relationship between price and quantity demanded. Exports are determined by the import decision of importing firms and the Armington function guarantees again that the export demand depends negatively on price. Given this negative demand curve, the firm has a constant returns to scale production function.

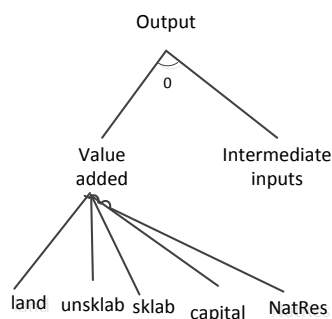


Figure 2-1 GTAP production structure

The production function is a Constant Elasticity of Substitution with two nests: one between intermediate inputs and value added as a whole, that normally has a substitution elasticity of zero, and a value added nest (figure 2.1). This implies that demand for intermediate inputs normally grows with the same rate as production, as does value added as a whole. When relative prices of production factors change, more or less production factors may be used. In this manner demand for production factors adjusts to relative availability of these production factors.

Normally total supply of production factors is fixed, or in case of scenarios, changed exogenously. This implies that for the model, the availability of production factors is determined outside the model. For the modelling of the production factors there are basically two mechanisms. The first, called mobile endowments (endowments is just production factors), price is adjusted till total demand for production factors (through adjustments made possible by the CES production function) equals supply. Capital and labour are considered to

be mobile production factors and therefore the changes in wages and the price of capital changes with the same percentage for all it and labour in one region.

The second type of production factors are called sluggish endowments, and there the percentage change of the price is dependent on the sector who is demanding this endowment. Sluggish endowments distribute their supply based on a Constant Elasticity of Transformation (CET) function that functions more or less in the same manner as a CES function, but then for the supply side. The argumentation behind the use of this CET function is that the endowment is not homogeneous, and therefore not suitable to the same level for all sectors. For example, very wet land may be very useful for rice production, but not for wheat production. It is assumed that each sector uses the land that is best suitable, and therefore when it likes to expand land use it has to be satisfied to get land of lower quality for its own purposes, and this implies that the implicit cost of using this land increases.

2.3.5 Investment

On a global level savings determine investments in a general equilibrium model. In standard GTAP there are two possible closures that distribute global savings over regions. The first is that there growth of net investment is equal in all regions, implying that rates of return may differ a lot in different regions. The other is that the expected rate of return is equalized in all regions. This condition is a little bit complicated in the sense that the expected rate of return is determined by the current rate of return and the difference between the growth of capital stock as determined by the exogenous shocks to the model, and the growth of capital stock that would emerge if the capital stock would grow according to the net investments made in the region. This last mechanism generates a faster increase in investment when the assumed growth of capital stock is higher, and therefore tries to force a little bit of consistency between short term investment and long term growth of capital stock.

2.3.6 Taxes and subsidies

As discussed when introducing the database, almost everywhere taxes can be implemented. All these taxes are considered to be ad valorem tariffs in GTAP, implying that they grow with the value of the tax base. For example, if the price of crude oil increases, the taxes increase with the same percentage as the rise in petrol price. This may be correct for a country like the USA, but for Europe taxes on petrol are mainly specific duties.

2.3.7 Conclusion

The GTAP model is a simple and for a large number of issues straightforward general equilibrium model of the world. In combination with its database it is a powerful tool to investigate interdependencies in the world economy. However, it is also obvious that the model focuses on general principles and is over-simplified for most real world analysis. For this reason, the model can only be seen as a starting point. In the MAGNET system the GTAP model is presented in a lucid manner, and there is an easy way to extend the model to make it more suitable for real world analyses.

2.4 Modified GTAP

For MAGNET a number of simple adjustments have been made to make the model more robust and to prepare the introduction of modules. First, it is handy to update population in order to have it available in later simulations. Second, an advanced method to calibrate technological shocks has been designed. While in standard applications total factor

productivity is shocked with the same rate for all production factors, in MAGNET there is a possibility to differentiate these shocks in a general manner. The basic equation is as follows:

$$af(i,j,r) = ASCALE(i,j,r)*aknreg(r)+DUM_I_LAND(i)*aland(j,r);$$

where:

- af is the percentage change in input productivity for input i in sector j in region r
- ASCALE is a parameter with the same dimension that tells with which factor the general increase in productivity in region r, aknreg(r), has to be multiplied.
- aland can be shocked separately from other production factors, where DUM_I_LAND is 1 for land and zero for other inputs.

With this equation you can tell that an increase in productivity in agriculture is for example three times as high as in services. The technology variable aknreg is calibrated by running the model with the growth of GDP exogenous.

Running standard GTAP requires that most parameters have a positive value. In cases there are zeros the model doesn't solve. In order to solve this problem, in the code of modified GTAP there is explicitly mentioned what has to be done when a variable is zero. For example, the equilibrium condition for the inputs of a production factor requires that supply (qoes) equals demand (qf).

$$qoes(i,j,r) - qf(i,j,r)=0$$

the price of the production factor (pmes) is implicitly determined by this equation through the supply and demand equations. However, when the quantity (VFM) is zero, no percentage changes are possible, and the other equations don't give a relationship between price and quantity anymore. In that case it has to be told that the percentage change of prices equals zero:

$$if(VFM(i,j,r)>0,qoes(i,j,r) - qf(i,j,r))+if(VFM(i,j,r)<=0,pmes(i,j,r))=0$$

In this manner MAGNET can work with real zeros everywhere for commodities that are not produced or used in some regions.

2.5 Flexible production structure

Standard GTAP has a very simple CES function for value added. Other versions of GTAP, like GTAP-E, have more complicated production structures with a hierarchy of nests. However this structure is the same for all sectors, and is not easy to adjust. In MAGNET a system has been developed where a CES production structure can be designed in a simple manner, and where different sectors can have different production structures. The basic design is simple: you first tell which sector uses which production structure. Then for each production structure a CES tree is built by first defining which the names of nests used, and then allocating inputs to all nests, where the output of each CES nest can be used as an input for another nest. Figure 2.2 gives a very simple example of such a CES tree definition. In the top row the CES nest names are defined, where the first, top_comm, is just the final output, vaen stands for value-added-energy, and ken, for capital-energy. Except for top_comm, the outputs of the nests can be used as inputs in other nests and so referred to in the first column. In the second column the inputs for the top_comm nest are mentioned, in this case other input (just one name for all inputs in this case) and vaen. Vaen is produced by using land, labor and ken as an input. And finally, ken is produced by a nest have petro (petroleum) and capital as inputs. In this manner all inputs are allocated to nests, and all nests that don't produce the final output are somewhere an input in another nest. This makes the system completely flexible and allows us to define a relatively complex production in the chapter on biofuels without much work in programming.

	top_comm	vaen	ken
Land	0	1	0
Labour	0	1	0
Capital	0	0	1
Petroleum	0	0	1
Otherinput	1	0	0
vaen	1	0	1
ken	0	1	0

Figure 2-2 Defining a CES structure

2.6 Dynamic consumption

When doing long term projections incomes may change considerably and with this the income elasticities. To capture such changes a module has been developed in which income elasticities are calibrated using ppp-corrected GDP per capita. In GTAP, private (household) consumption behaviour is modelled via a Constant Difference of Elasticity (CDE) function, which is a relatively flexible, non-homothetic function allowing for non-constant marginal budget shares, and is calibrated by GTAP using data on income and price elasticities of demand. Since the use of the CDE function in practice results in constant income elasticities over time – leading to unrealistically high consumption of food items in fast growing economies – in MAGNET income elasticities may be adjusted over time using real (PPP-corrected) GDP per capita.

The basic idea is that in each calculation step of the model (i.e. a small period of time) the CDE consumption function parameters of GTAP are recalibrated on target income and price elasticities of consumption. The parameters and functional form used to calculate these income elasticities is based on the relationship between GDP and income elasticity that has been found in the GTAP database. Because experience showed that the income elasticities in standard GTAP were too to be plausible, the function is shifted downwards to have plausible calorie intakes also in the long term. A shifter for the function has been added to allow for shifting the function based on specific information like estimated elasticities in TAPSIM project.

For price elasticities the standard GTAP values are taken except when it is defined otherwise. In case of TAPSIM the target price elasticities of consumption for India have been replaced for price elasticities found in other deliverables of the TAPSIM project for those commodities these elasticities have been estimated.

2.7 Labor mobility between agricultural and non-agriculture

The standard GTAP model assumes that labor can move easily from one sector to another. With respect to agriculture this seems not consistent with the facts. There is a general tendency of agricultural income to develop relatively independent from other sectors. The reason in developed countries is that farmers are in many cases reluctant to move to other jobs because it is a type of life style, while in developing countries people working in agriculture would have to migrate to get a job in another sector, while also education may be lacking. For this reason, the outflow of labor from the agricultural sector is relatively slow.

In order to include this principle, a function has been estimated that explains the outflow of labor from the agricultural sector by the relative wage:

$$qoagr(i,r) = \text{DYNAGNAG}(i,r) * \left(\frac{\text{PAENDWM}_{i,r}}{\text{PNAENDWM}_{i,r}} - 1 \right) * 100 * \text{time}$$

where the percentage change in the quantity of labour or capital (i) used in agriculture (qoagr) in each region (r) is determined by the relative wage of the two sectors, the time period and a speed of adjustment parameter (DYNAGNAG). The initial difference between the agricultural and non-agricultural wage levels is taken as indicative of the reservation wage in agriculture. In first instance, the wage in each market is set to 1. A value of 0.07 is used for the speed of adjustment between the two markets based on econometric estimation. A full description of the estimation of the agricultural employment equation and the econometric estimation can be found in Tabeau & Woltjer (2010).

The consequence of this principle is that an increase in demand for labour in agriculture, for example as a consequence of biofuel policies, will increase agricultural income per worker in the short term, but in the long term the development of agricultural income is determined by the general development of wages in the economy because people will leave the agricultural sector in the long term if it is more beneficial to work elsewhere.

2.8 Land supply

2.8.1 The land supply curve

The land market in standard GTAP is extended in MAGNET with an explicit land supply function. The basic idea is that supply of agricultural land depends on average land price. This land price is calculated as a weighted average of land prices for different land uses. An increase in agricultural land price either implies less urban land use, or less land use for nature. The asymptote is defined as the maximum amount of land that is available for agriculture, and it seems plausible that land price increases when agricultural land use increases. This idea behind the land supply function is illustrated with the land supply curve in figure 2.3. The land supply curve shows that if the land rental rate, i.e. the price of land, increases, the amount of land that will be taken into cultivation rises. When a lot of unused land is still available, the land supply curve is about horizontal. In the curve of figure 2.3 an increase in demand from D1 till D1' generates a large increase in land use from Q1 till Q1', and a small increase in rental rate from P1 till P1'. In a country where current land use is nearer to the asymptote, an increase in demand from D2 till D2' generates a small increase in agricultural land use from Q2 till Q2', and a relatively large increase in land rental price from P2 till P2'.

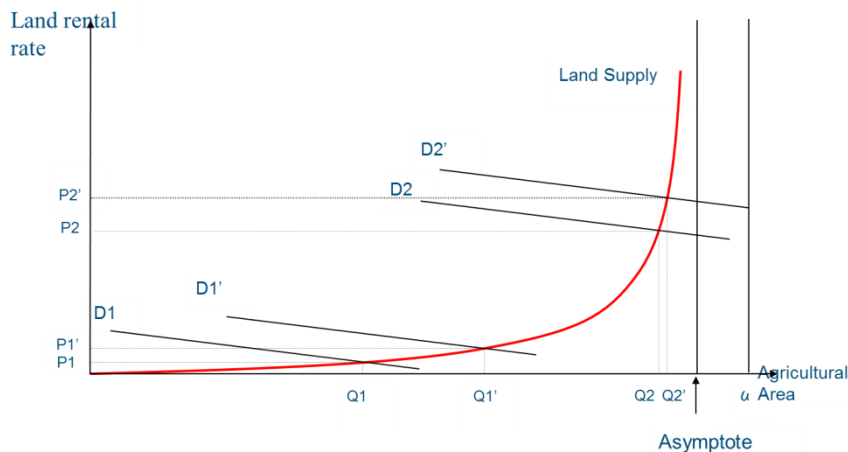


Figure 2-3 The land supply curve

It is not easy to find a good foundation for the land supply elasticities used to calibrate the land supply curve. The calibration of the land supply elasticity function was originally based on the land productivity as defined in the land use model IMAGE from PBL. The idea was that in first instance land with high land productivity would be used and when land use would expand less and less productive land would be taken into production. This idea was not consistent with what determined land allocation in IMAGE. In IMAGE grids are defined for 0.5x0.5 degree spatial resolution, about 50x50 km, and for each grid cell IMAGE calculates suitability based on a very rough indicator function. Suitability is the sum of indexed suitability between 0 and 500 for population density, distance to main water infrastructure, and a random factor, with land productivity having a negligible influence. It adds an indicator between 0 and 1 to the calculated suitability, where cells with land productivities of less than 10% of the maximum are not included in the land allocation procedure. This implies that there are enormous differences in land productivities of cells with the same suitability. Land is allocated from highest to lowest land suitability, starting from the current land allocation.

Knowing that the suitability values in IMAGE have not much to do with land prices, a much easier approach for calibration of the land supply function was developed. The function was simplified. Two basic logical requirements form the starting point: the elasticity of land supply is zero when land supply equals the amount of available land, and approaches infinity when land use approaches zero. The function was calibrated on one other point: when 50% of available land is used, we assumed that the price elasticity of land supply equals 4, but by changing a parameter this could be easily adjusted.

Information about suitability may be used to derive a land supply function for MAGNET. But this is a risky business. For suitability only an ordinal scale is required, while land price is a cardinal scale. By weighting the different elements in calculating the suitability index, some cardinality is also implied. For example, with a population density index of 500 an increase of 1 in distance to infrastructure is assumed to have the same effect as the increase of 1 in distance to infrastructure with a density index of 200. So, the better the suitability index in IMAGE is based on a correct and statistically estimated function, the better will be the cardinal properties of the index.

2.8.2 Allocation of agricultural land with a nested CET function

The standard version of GTAP represents land allocation in a constant elasticity of transformation (CET) structure (left side of Figure 2.4) assuming that the various types of land use are imperfect substitutes. This simple land use allocation structure with equal substitution elasticities between all land uses is extended by creating a nested three-level CET-structure that takes into account that the degree of substitutability differs between types of land using the elasticities from the OECD Policy Evaluation Model (Huang et al, 2004) in a nested three-level CET structure (right part of Figure 2.4). In this structure it is assumed that for example wheat and oilseeds are easier to substitute than horticulture and field crops, i.e. that $\sigma_3 > \sigma_2 > \sigma_1$.

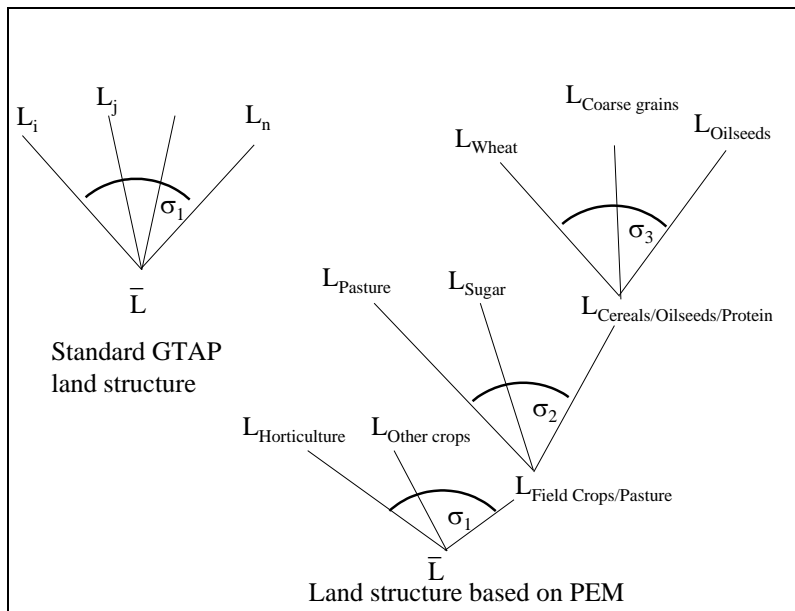


Figure 2-4 Land allocation tree in MAGNET

The basic approach with the PEM nesting structure has been generalized for MAGNET to the possibility to create all types of nesting CET structures using the same principles as discussed for CES functions in the section on the flexible production structure. One of the nesting structures used includes also forestry as a sector, where the top nest substitutes between crops, livestock and forestry. Based on estimates from Purdue university this CET elasticity was set at 0.2, i.e. a very low value. But even for the other elasticities normally values less than 1 are used.

The rationale for the CET functional form may be interpreted in three ways (see for the first two Baltzer and Kloverpris, 2008: 20-1). First, different types of land have different productivities for different products. If the land is allocated more or less optimally to the different sectors, a change in allocation implies that the expanding sector has to use less productive lands, while the sector that reduces its land use may get rid of land with a lower than average productivity. As a consequence, a switch of production will generate an increase in the number of hectares needed.

Second, an increase in variety of production implies more opportunities for crop rotation, and therefore a higher land productivity. Although this may be the case for substitution between crop products, this cannot be defended for substitution between grassland and cropland.

Third, practice shows that farmers do not switch to different crop types immediately. A change in crop may require some investment or at least some adjustment in production processes. Especially changes between grassland and cropland may require adjustments in the production process. Uncertainty and adjustment costs will delay this process, even if productivities may not be involved. To the extent that this dynamic process is relevant, a dynamic formulation of land adjustment would be required, implying that in the short run the effect of differences in rent between different sectors generate only small adjustments in land allocation, while after a long time the elasticity of transformation may be almost infinity. The combination of the lines of reasoning above would imply a lower elasticity of transformation in the short run than in the long run.

In summary, the current implementation of the land market is a combination of the land supply curve and a CET function to distribute land use over different sectors.

2.9 Biofuel directive

In analyzing biofuel policies in many cases targets are formulated based on which in many cases blending requirements are forced on the petrol sector. In order to model this a module has been developed that is able to target these blending requirements for petrol use in the transport sector. Because the use of petrol in transport is not explicitly in the database, additional information had to be found. The International Energy Agency supplies information on petrol use in the transport sector as well as on the production of biofuels. Based on this the share of biofuels in the transport sector can be calculated.

In order to model the development of this biofuel share, it is assumed that petrol use in transport sector grows with the same percentage as general petrol use. The model can then be forced to have a certain blending percentage by changing the subsidy to biofuel use in the petroleum sector. This gives an important problem: a subsidy is given to the petroleum sector, while normally the petroleum sector has to pay for it. Therefore, a balance equation is added that puts a tax on the use of petrol that exactly balances the subsidy on blending. In order to prevent that the CES function used for the substitution between biofuels and fossil fuels distorts the relative prices a lot, the elasticity of substitution has to be set at a very high level.

In summary, the biofuel directive module provides the opportunity to set blending targets for the petroleum industry without giving subsidies by applying some handy tricks. The module is programmed in such a manner that also blending targets for other sectors can be implemented.

2.10 Conclusion

MAGNET is based on the GTAP model, but has replaced and extended the model a lot. A strong point of GTAP is its database that describes the global economy in a consistent manner. The strong point of MAGNET is its flexibility to include new modules that are consistent with the rest of the model, and its systematic data adjustments. At this moment the flexible production structure, PPP depending income elasticities of consumption, a dynamic labor mobility function between agriculture and non-agriculture, a biofuel directive module, and endogenous land supply through a land supply curve and a nested CET function are characteristic for the standard MAGNET applications. In the rest of this deliverable a number of additions to MAGNET in the context of TAPSIM will be discussed.

3 Data adjustment

3.1 Introduction

The data in a database are never perfect. Especially for a database like the GTAP database it is impossible to have the world completely consistent, and all numbers in all countries right. Therefore, in specific projects the database has to be adjusted to the requirements of the specific country under research. In TAPSIM the international model MAGNET is assumed to be more or less consistent with the national CGE model of India developed by the Indira Gandhi Institute of Development Research (Deliverable 6.2). Also information about the development of supply and demand in India as analysed in a TAPSIM study by Joshi and Kumar (Deliverable 5.1) has to be integrated in the approach of the international modelling exercise.

In order to improve consistency, a lot of effort has been taken to adjust the sector aggregation of MAGNET to that of the national CGE model (section 2.2). The regional aggregation has been kept simple.

When a decision has been made about the aggregation level, the challenge is to adjust the data, summarized in a Social Accounting Matrix (SAM), to the information available in India. A general procedure has been developed to adjust a national SAM in the international CGE model. The procedure is semi-automatic, and a lot of effort is put into getting a consistent and plausible SAM in the end. The specific circumstances in 2006/7 and the large differences with the numbers in the GTAP database, suggested not to accommodate to all changes in the database (section 2.3).

A next decision is about income and price elasticities of consumption. The study by Joshi and Kumar provides information about their perception of the elasticities, and the elasticities in the MAGNET model are compared to them. Based on this comparison parameters of the income elasticity formula have been changed (section 2.4). Finally, technological change is very important. In general, the MAGNET model has a tendency of decreasing prices because technology in agriculture is assumed to develop fast. Current predictions are a decreasing growth of agricultural productivity, and this assumption has been implemented in the current version of the model (section 2.5). The current status of the adjustment procedures is discussed in the final section.

3.2 Aggregation level

3.2.1 Introduction

3.2.2 General method to change aggregation

A lot of effort has been done to make the aggregation system in MAGNET more flexible and robust. In first instance a procedure has been developed for the old LEITAP model to do this in a systematic way. The introduction of the modular system in MAGNET required revision of the procedures. Procedures to improve and change data are now implemented at the lowest GTAP aggregation level. The choice of model aggregation from GTAP towards a project specific MAGNET aggregation is combined with a choice of modules used in the simulations. For example, a module that focuses on the details of EU agricultural policy is not useful for India, and therefore can be switched off. For all additional MAGNET data aggregation procedures are defined where in first instance the additional data are aggregated

to the GTAP data level (that can be extended with new sectors when extra data are available) and then these data are aggregated towards the level used in the actual model application.

An important advantage of the chosen procedure is that it is easy to switch towards newer versions of the GTAP database when they become available. With the TAPSIM project we started with the version 6 database of 2001, then switched to the version 7 database of 2004, and now we are working with the version 8 database with data of 2007. The different database versions have different region definitions, and the developed aggregation program is completely flexible to adjust to these changes in aggregation. This implies that the model for TAPSIM can be easily updated when newer databases become available.

In developing the MAGNET data system, an interface has been built to add new sectors to the GTAP database. This procedure just adds zeros for the new sector, so the crucial point is to fill the new sector with reasonable numbers. Examples of this type of procedure are discussed in the chapter on biofuels and agriculture. This chapter makes clear that such a procedure requires a lot of extra data, so, although the developed procedures simplify work a lot, adding new sectors will remain a labor intensive activity.

3.2.3 Sector aggregation

The challenge during the TAPSIM is to make the commodity aggregation within the MAGNET model as consistent as possible with the national CGE model. Table 2.1 shows the relationship between the GTAP sectors and the national model sectors. Based on this table we decided for an aggregation of the GTAP sectors towards MAGNET sectors for the TAPSIM project (table 2.2). All sectors of the national model that have a related sector or group of sectors in the GTAP database are defined, and some extra sectors are defined that may be useful for the simulations.

In this mapping some problems remain that cannot be resolved easily. As far as one of the models has a more refined aggregation, we can aggregate results to a common level for aggregation, and apply the percentage change from one model for all subsectors of this commodity in the other model. An example is the sector Vegetables and fruits in GTAP (v_f) that is split into vegetables, fruits and pulses in the national Indian model. More complicated is the definition of the important Indian commodity cotton in the Indian model. In the GTAP database all plant based fibres are taken together in one sector (pfb), while the Indian model splits out cotton and adds the fibres to the sector other crops. So, we don't know the other fibres. Assuming that the other plant based fibres are relatively small for India, we will apply the percentage changes for plant based fibres in GTAP directly to the cotton sector in the Indian model.

A next issue is the production of animal products. In the GTAP database there are two sectors, i.e. cattle and other animal products. In the other animal products chicken, eggs pork and some other commodities are taken together. In the national Indian database the sector chicken and eggs is taken out, while pork and cattle are together in their sector of other animal products. This inconsistency cannot easily be solved. Because the pork sector is small in India, the problems may be relatively limited.

A third issue is the inclusion of processing sectors in the Indian primary agricultural sectors. In first instance, the pragmatic solution was chosen to aggregate the processing sectors also in the primary sectors in the MAGNET database. So, dairy and milk, cattle meat and cattle, other meat and other animal products are integrated in three MAGNET sectors milk, cattle, and other animal products. For comparison with the Indian results this is still the case, but we have decided to use the extra detail of splitting the sectors in a primary and a processing part by running the model at the more detailed level.

Table 3-1 Mapping of GTAP sectors to sectors in the Indian CGE model

GTAP sectors(57)		Corresponding National SAM sectors (32)
pdr	Paddy rice	Paddy
wht	Wheat	Wheat
gro	Cereal grains nec	Other cereals
v_f	Vegetables, fruit, nuts	Split into Vegetables, Fruits and Pulses
osd	Oil seeds	Oilseeds
c_b	Sugar cane, sugar beet	Sugarcane
pfb	Plant-based fibers	Split into Cotton, other fibers are in other crops
ocr	Crops nec	Other crops
ctl	Bovine cattle, sheep and goats, horses	Other animal products
oap	Animal products nec	Poultry & Eggs
rmk	Raw milk	Milk and milk products
wol	Wool, silk-worm cocoons	Other animal products
frs	Forestry	Primary products
fsh	Fishing	Fishing
coa	Coal	Primary products
oil	Oil	Primary products
gas	Gas	Primary products
omn	Minerals nec	Primary products
cmt	Bovine meat products	Other animal products
omt	Meat products nec	Poultry & Eggs
vol	Vegetable oils and fats	Vegetable oils
mil	Dairy products	Milk and milk products
pcr	Processed rice	Paddy
sgr	Sugar	Sugar
ofd	Food products nec	Other food products
b_t	Beverages and tobacco products	Beverages & Tobacco
tex	Textiles	Textiles & garments
wap	Wearing apparel	Textiles & garments
lea	Leather products	Manufacturing-1
lum	Wood products	Manufacturing-1
ppp	Paper products, publishing	Manufacturing-1
p_c	Petroleum, coal products	Petroleum products
crp	Chemical, rubber, plastic products	Split into Fertilizers, Pesticides and rest is put into Manufacturing-1
nmm	Mineral products nec	Manufacturing-2
i_s	Ferrous metals	Manufacturing-2
nfm	Metals nec	Manufacturing-2
fmp	Metal products	Manufacturing-2
mvh	Motor vehicles and parts	Manufacturing-2
otn	Transport equipment nec	Manufacturing-2
ele	Electronic equipment	Manufacturing-2
ome	Machinery and equipment nec	Manufacturing-2
omf	Manufactures nec	Manufacturing-2
ely	Electricity	Electricity
gdt	Gas manufacture, distribution	Petroleum products
wtr	Water	Water supply
cns	Construction	Construction
trd	Trade	Trade
otp	Transport nec	Transport services
wtp	Water transport	Transport services
atp	Air transport	Transport services
cmn	Communication	Other services
ofi	Financial services nec	Other services
isr	Insurance	Other services
obs	Business services nec	Split into Storage and warehousing, and Other services
ros	Recreational and other services	Other services
osg	Public Administration, Defense, Education, Health	Other services
dwe	Dwellings	Other services

A next problem is that in the Indian database the GTAP chemical sector (crp) is split into three parts: fertilizer, pesticides and the rest, where the rest is included in one big industrial sector called Manufacturing 1. Because of the importance of fertilizer and pesticides it is useful to split a fertilizer and pesticides sector from the chemical sector in the GTAP database assuming that all supplies to the chemical sector to the primary agricultural sectors are fertilizer and pesticides, and that the input structure of the fertilizer and pesticides sectors

together gives a first indication of the input structure of this sector, also for the rest of the world. This has been accomplished now.

Table 3-2 Magnet India final commodity aggregation

Commodity	Commodity description
pdr	Paddy and processed rice
wht	Wheat
grain	Cereal grains nec
oils	Oil seeds
sug	Sugar cane, sugar beet
hort	Vegetables, fruit, nuts
pfb	Plant-based fibers
othcrops	Crops nec
cattle	Cattle, sheep, goats, horses, wool
oap	Pigs, poultry
milk	Raw milk
dairy	Dairy products
sugar	Sugar
vol	Vegetable oils and fats
cmt	Meat: cattle,sheep,goats,horse
omt	Meat products nec
ofd	Other food, compound feed
bevtab	Beveridges and tobacco
fsh	Fishing
frs	Forestry
c_oil	Crude oil
petro	Petroleum, coal products
biod	Biodiesel
biog	Ethanol
gas	Gas mining, production, distribution
gdt	Gas manufacture, distribution
coa	Coal
ely	Electricity
watersup	Water supply
chem	Chemical industry
manu1	Manufacturing sector 1
manu2	Manufacturing sector 2
ser	Services
tex	Textiles
minerals	Minerals nec
construction	Construction
trade	Trading sector
transport	Transport services
ddgs	Distiller's dried grains and solubles
mola	Molasses, byproduct of sugar production
oilcake	Oil cake as byproduct of cvol industry used as ani
fert	Fertilizer
feed	Animal feed
cvol	Crude vegetable oil

Storage and warehouses in Indian model is part of other services in MAGNET. So, storage, warehousing and other services are services in MAGNET. This implies that it is not easy in the MAGNET model to make a clear analysis of the effects of a structural change towards a more advanced food distribution system.

In order to create a possibility to analyse biofuel policies and tackle agricultural intensification better, a number of sectors has been added that are related with biofuels. First, there is biodiesel and biogasoline (i.e. ethanol). Then there is the byproduct of ethanol production from maize, i.e. DDGs. Third there is the most important input for biogasoline production in India, i.e. molasses, that is a byproduct of sugar production. Fourth, there is a split in the vegetable oil sector in a crude vegetable oil sector that splits oilseeds into vegetable oils and oilcake, and a refined vegetable oil sector that does the further refining of the vegetable oil in sophisticated products for consumers. Fifth, in order to model the substitution between the biofuel byproducts and other animal feed, the sector ofd has been split in a feed sector and an “other food” sector (ofd). Finally, in order to model intensification, a fertilizer (fert) has been split from the chemical sector.

3.2.4 Regional aggregation

For the regional aggregation the decision has been made to model the main regions in the world plus the regions surrounding India. Because the data reliability of the direct neighbours of India is low, they are put together into one region, Rest of South Asia. The EU is aggregated towards one region because this simplifies the analysis of trade policies, that apply to the EU as a whole. The complete aggregation is presented in table 5.3.

Table 3-3 Magnet India regional aggregation

Region	Region description
EU27	EU27
can	Canada
usa	USA
mex	Mexico
rca	Rest of Central America
bra	Brazil
rsa	Rest of South America
caf	Central Africa
saf	South Africa
rwe	Rest of Western Europe
ree	Rest of Eastern Europe
tur	Turkey
rfsu	Rest of Former Soviet Union
rus	Russian Federation
nafme	North Africa and Middle East
india	India
rsas	Rest of South Asia
korjap	South Korea and Japan
chi	China, Hong Kong, Mongolia and Taiwan
sea	South-East Asia
indo	Indonesia
oce	Australia, New Zealand and Rest of Oceania

3.2.5 Conclusion

Given the GTAP database aggregation, the chosen MAGNET aggregation for TAPSIM is as near as possible to the national CGE database. A procedure has been developed for

MAGNET to be able to change to other aggregations relatively easily and newer databases of GTAP when they become available. A possibility has been created to split off sectors and commodities relatively in an easy manner. This has procedure has been used for fertilizers, biogasoline, biodiesel, molasses, DDGs, crude vegetable oils, oilcakes, and animal feed.

3.3 The SAM of India

3.3.1 Introduction

When the project was started, we used the version 6 GTAP database with data for 2001. The SAM used in the national Indian model was from 2006/7. Therefore, it seemed logical to adjust the GTAP SAM for India during the simulation by applying shocks to make the GTAP SAM consistent with the national Indian SAM in 2007. During the project GTAP release 8 became available that has data for 2007 using much more recent data on India. This implies that the adjustment procedure was not very relevant anymore for running simulations with the new database. Nevertheless the procedure will be discussed in this section because the developed procedures will be relevant for future analyses and because it will be relevant for adjusting databases of other countries. For TAPSIM some procedures developed for the adjustment of the database are used in the database adjustments needed when new sectors are introduced, as discussed in chapter

Starting with specific procedures for India a module has been developed that is able to adjust the SAM of a country in the GTAP database towards targets defined by national data, in this case the SAM of the national Indian model. The basic line of thought behind this procedure is as follows.

3.3.2 Basic principles

Because sector definitions of the national SAM are normally not consistent with those of the GTAP database, the challenge is to develop procedures that maximize consistency between the two databases by applying the least aggregated common aggregation of the two SAMs. The information from the national SAM is first aggregated to the common aggregation, as is the SAM information from MAGNET. Then the percentage difference between the two SAM's can be calculated. The percentage difference calculated in this way can be applied to all MAGNET sectors that are part of the common sector. This implies that the relative position of the subsectors of the common aggregation sector remains the same in the GTAP or MAGNET database. In this way optimal use is made of the available information in the two databases, i.e. the national SAM and the GTAP database.

Another starting issue of synchronizing a GTAP SAM with a national SAM is that the two are normally defined in different currencies and in many cases also different years. GDP seems to be a commonly agreed indicator of national welfare that is measured consistently. Therefore, to adjust the GTAP database all information is formulated as share of GDP, and this share of GDP is multiplied with GDP in the GTAP database in order to get common ground. In this manner, implicitly a conversion rate between the GTAP unit of measurement and the national unit of accounting is created. This can be stored in the database.

3.3.3 International trade

The most influential change of a national SAM in an international database is the adjustment of imports and exports. Because in the national SAM no information is available about regional source and destination of the commodities, the current distribution of regions in the GTAP database is used; basically all commodity import respectively export flows between India and the other countries are multiplied with the same percentage as the total imports

respectively exports of India for that commodity. To prevent large distortions, first a check is made if the SAM of the country can accommodate the change easily through consumption and investment. If this is not the case (we use a maximum of 10% adjustment) then first it is tried to apply the adjustment to other countries. Only when this is not possible, also intermediate inputs are adjusted in countries. The disadvantage of adjusting intermediate inputs is that this influences production value of the sectors using the intermediate inputs, or that the change in intermediate input demand has to be compensated by a change in other intermediate inputs. In this way the distortion of databases in other countries is minimized.

In many cases the pattern of production is an essential characteristic of a database. Because the total of production depends on aggregation definitions, it seems more reliable to define the production values as percentage of GDP. Therefore, the procedure starts with the use of production per sector as percentage of GDP. A first step is to calculate percentage changes of production as share of GDP required to make the MAGNET database consistent with the national database in production values.

A second step is to calculate the percentage change in input shares for these sectors. If both percentages are applied, the two databases become consistent with respect to the input-output table.

With respect to the Indian database compared with the GTAP database there is an inconsistency with respect to the handling of imports. While in the Indian model and database all demand is added together and then distributed over imports and domestic production, in the GTAP model and database for each demand category (i.e. each input in production) demand is distributed over imported demand and domestic demand. So, in shocking the MAGNET database, a decision has to be made about the distribution of imported demand per sector. A logical way to do this is to keep the distribution as it is, but to scale the total imports towards the target imports as defined in the national database or as it is in the GTAP database. This scaling can only be done when also demand for private and government consumption have been determined.

3.3.4 Production, consumption and investment

The next step is to target private consumption, government consumption and investment demand as percentage of GDP. Hopefully, these shocks address already a large part of the inconsistencies that have been created in the Indian database of MAGNET. When a consistent national SAM is the base of adjustments, the probability that large inconsistencies at the national scale emerge is not very big.

3.3.5 Removing inconsistencies

Although adjustment of the GTAP SAM of India towards a consistent Indian SAM will probably generate not too many inconsistencies, some inconsistencies because of different sector definitions and a different organization of the SAM cannot be avoided. With respect to the trading partners of India the adjustments of bilateral trade will by definition create inconsistencies in those countries. Therefore, at the end of the adjustment procedure a number of routines is required to balance the SAM of India and the SAMs of Indian trading partners. When balancing the SAM the challenge is to force required adjustment in the SAM at places where it hurts the least.

We have developed the following order of adjustment. Because private consumption, government consumption and investment are final demand categories these numbers can be adjusted without having influence on the rest of the system. For this reason, we first try to balance supply and demand through this mechanism. When these adjustment would change the results too much or are not possible because of insufficient final demand, a second line of

defence is the adjustment of input coefficients for sectors. This has the disadvantage that when these coefficients are changed either production of the sectors for which the inputs are used changes, or compensatory adjustments in other inputs must be created, and this will generate the need for a further adjustment of these sectors or commodities. A last line of defence is the adjustment of production.

As far as inconsistency are in the newly created SAM, private consumption, government consumption and investment are corrected adjusted with the same percentage in order to equalize supply and demand of commodities.

The final step is to adjust the import shares of all demand categories to a level that is consistent with the target imports.

In order to check for implausible end results, the shocks needed to adjust the new MAGNET SAM towards the Indian SAM are recalculated, showing how much inconsistencies remain. Also the percentage and absolute changes in the SAMs of other countries are calculated to see explicitly how much distortion is created. Only percentage differences of more than a certain percentage are reported, in order to prevent an overload of information.

In summary, the adjustment of the GTAP SAM towards a national SAM is a relatively simple procedure that puts adjustment at well-defined places. The required percentage changes are mostly standardized by formulating them as a share of GDP, and at the end of the procedure a check on distortions is reported.

3.3.6 Conclusion

A systematic adjustment procedure for data in a national SAM has been developed for TAPSIM. This has been applied during the first stages of the project, when only version 6 of the GTAP database based on a SAM of India for 1994 was available. When version 8 of the GTAP database became available, the information for India was based on a SAM of 2003 instead of 2003 and adjustments became much less important. The problem that in adjusting a database you always mess up a little bit the database and especially the part of trade that is very well developed in the GTAP database, led to the conclusion that it was better not to adjust the database when the new release became available. Because the adjustment procedures are very general, it is easy to apply them when necessary when information becomes available, while the procedures that have been developed can be used for other purposes, like the ones developed for the inclusion of new sectors and commodities as discussed in chapter

3.4 Income and price elasticities of consumption

In order to synchronize the national CGE and MAGNET with respect to consumption, the income and price elasticities of consumption have to be synchronized. For the initialization of the MAGNET database a calibration procedure for the consumption function is implemented, where income and own price elasticities are targeted. The price elasticities are those that are implemented in the standard database, while the income elasticities are calculated by a formula that relates GDP per capita and income elasticity. Because this formula is used for the whole world, in order to get consistent results we would like to adjust the formulas for the whole world. For this reason, only larger differences are accommodated for. The practical adjustments are discussed in the chapter about the baseline.

3.5 Conclusion

For TAPSIM a tailor made aggregation has been developed, including procedures to make the adjustment of aggregations easy. Also procedures to adjust the SAM in the GTAP database to information from national sources has been developed, including adjustments needed in other regions of the world if trade flows change. Finally, a procedure has been developed to use income and price elasticities from national sources in the MAGNET model, either by shifting the function that generates the income elasticities for all regions of the world, or by just fixing the values of the income and price elasticities.

4 Dynamic international investment

4.1 Introduction

The Indian economy is opening up towards international trade and capital flows. For this reason it may be useful to introduce these capital flows explicitly in the model. Ianchovichina and McDougall (2001) designed a model structure to include international capital and international capital income flows into the GTAP model. The accounting system is used for the dynamic international investment module of MAGNET, but the complicated dynamics that is derived from the standard GTAP model seems overly complicated, not completely consistent and counter-intuitive. For this reason in this chapter a more lucid model of international investment is introduced that simply starts with the two main decisions: how much do you invest internationally, and how are the international investment funds distributed over different regions? So, the dynamics of capital inflows and outflows is derived from the current investment streams. There are two main decisions modeled. First, the decision to invest available domestic funds either domestically or internationally. The current distribution of these investment streams is taken as a starting point, where the relative profitability of the two types of investment redirects those investment streams gradually. It is assumed that a fixed part of current international and domestic wealth can be reallocated, while also new savings can be allocated.

All international investments are put together at the international trust, and this trust decides about adjustment of the investment streams over different allocation on the past and relative profitability (including risk premiums). The sum of domestic and international capital streams determine funds available for investment, and therefore the change in capital stock and production of the capital goods sector.

4.2 International capital and capital income accounting

The system of international capital flow accounting is derived from Ianchovichina and McDougall (2001), but while Ianchovichina and McDougall derive the international wealth positions from the international capital income flows, we derive the international capital income flows from the international wealth positions.

Below we describe the wealth accounting from the logic of investment. The starting point is the wealth of the Regional Household, WQHHL, where the first letter stands for Wealth, the second for eQuity, and HHL is the source sector, in this case the household. Wealth equals the value of the capital goods where the regional household has invested in. For a coefficient the last part (in this case HHL) is expanded to a somewhat longer name, while the variable has only the first character of this name (i.e. h). So, the variable wqh is the percentage change in WQHHL. This wealth can be either invested in domestic Firms, i.e. WQH_FIRM, or internationally (WQH_TRUST), where international investment is modeled as if there is an international Trust where you can invest in.

The sum of investments of all regional households into the international trust, WQ_TRUST, is invested by the trust in firms in the world. So, WQ_TRUST, the wealth invested in the international trust, equals WQT, the money invested by the international trust in different countries that is represented by WQTFIRM. The value of capital that is available for the domestic firm WQ_FIRM is the sum of wealth invested by domestic households, WQH_FIRM and the wealth invested by the international trust, WQTFIRM. This completes the wealth accounting scheme.

The capital income accounting system follows exactly the same structure, where Y stands for capital income. The starting point is the net capital income from the firm, i.e.:

$$\text{Formula (all,r,DINC_REG) } YQ_FIRM(r) = \text{sum}\{j, \text{ENDWC_COMM}, \text{VOA}(j,r)\} - \text{VDEP}(r);$$

Where YQ_FIRM is the capital income generated by the firms, and this equals the income for capital (VOA for ENDWC_COMM) minus depreciation. DINC_REG is just all the regions in the model when the international investment module is switched on. This income is distributed over the implicit owners of the firm consistent with the share of ownership. So, the regional household earns:

$$\text{Formula (all,r,DINC_REG) } YQH FIRM(r) = (\text{WQH FIRM}(r)/\text{WQ_FIRM}(r))*YQ_FIRM(r);$$

And the global trust earns from its investment in the regional firm what is left over:

$$\text{Formula (all,r,DINC_REG) } YQT FIRM(r) = YQ_FIRM(r) - YQH FIRM(r);$$

Total income of the global trust is simply the sum of the capital earned in all regions:

$$\text{Formula } YQTRUST = \text{sum}\{r, \text{DINC_REG}, YQT FIRM(r)\};$$

And this income is distributed over the different regional households according to their share in the wealth of the global trust:

$$\text{Formula (all,r,DINC_REG) } YQHTRUST(r) = (\text{WQHTRUST}(r)/\text{WQTRUST}) * YQTRUST;$$

Finally, total capital income of the regional household equals the sum of income from domestic firms and income from the global trust:

$$\text{Formula (all, r, DINC_REG) } YQH HLD(r) = YQH FIRM(r) + YQHTRUST(r);$$

There is one complication left: who pays the taxes on capital income. As shown above, the international capital flows are flows at agent prices, i.e. after taxes. So, all taxes on capital income flow into the regional household of the region where the capital income is generated. This capital tax income is defined as:

$$\text{Formula (all,r,DINC_REG) } \text{TINCC}(r) = \text{sum}\{i, \text{ENDWC_COMM}, \text{VOM}(i,r) - \text{VOA}(i,r)\};$$

Where VOM is income at market prices, and VOA is income at agent prices, i.e. after taxes are paid.

So, in the module with international capital dynamics the income of the regional household differs from income earned in its region depending on its position in international wealth.

Where in standard GTAP income is defined as

$$\text{INCOME}(r) = \text{sum}(i, \text{ENDW_COMM}, \text{VOM}(i, r)) + \text{INDTAX}(r) - \text{VDEP}(r)$$

In the model with international capital flows it is defined as:

$$\text{INCOME}(r) = \text{sum}(i, \text{ENDWNC_COMM}, \text{VOM}(i, r)) + \text{INDTAX}(r) + (\text{YQH FIRM}(r) + \text{YQHTRUST}(r) + \text{TINCC}(r))$$

Where ENDWNC_COMM is the non-capital endowments, ENDW_COMM is all endowments, i.e. including capital endowments, VDEP is the value of depreciation to create net capital income, and INDTAX is the sum of all indirect taxes.

As a consequence of the change in the flow of capital income, also savings may change. In order to guarantee consistency savings are calculated in the model and not read from the file with base data:

$$\text{SAVE}(r) = \text{INCOME}(r) - \text{PRIVEXP}(r) - \text{GOVEXP}(r);$$

This equation guarantees that the savings in the model are consistent with the choice made with respect to international capital dynamics or the standard GTAP closure.

4.3 Initialization of international capital accounts

The basic principle of the initialization of the international capital accounts is that consistency requirements are generated within the model code. For this reason, only two coefficients with respect to international wealth have to be read from the file with base data: WQHTRUST and WQTFIRM. These coefficients are updated.

Update (all,r,DINC_REG) WQHTRUST(r) = wqht(r);

Update (all,r,DINC_REG) WQTFIRM(r) = wqtf(r);

All other coefficients of the wealth and international capital income accounting schemes can be calculated from these coefficients when the information is combined with the information of the value of the capital stock VK:

Formula (all,r,DINC_REG) WQ_FIRM(r) = VK(r);

Formula (all,r,DINC_REG) WQHFIRM(r) = WQ_FIRM(r) - WQTFIRM(r);

Formula WQTRUST = sum{r,DINC_REG, WQTFIRM(r)};

Formula (all,r,DINC_REG) WQHHLDR(r) = WQHFIRM(r) + WQHTRUST(r);

So, in the model code the logic of initializing the accounting system is followed, as described in this section, while in the introduction of the accounting system we followed the logic of investment theory that will be developed in the next section. The accounting system is also implemented as equations, that is nothing else than the differentiated formulas.

4.4 International capital allocation theory

The basic idea of the international capital allocation is that streams in the past are adjusted gradually according to relative profitability. We start with the definition of the funds that are available for reallocation for the regional household and distribute this over domestic and international investment.

4.4.1 Calculation of wealth change of regional household

The calculation of wealth of the regional household requires careful thinking. The first step is the calculation of the prices relevant for revaluation of the funds that are invested. For domestic investments that is easy: just the price of investment goods. For the international trust the price (pwgh) is the weighted average of the price (we skip the definition of the equation and its reference to the regions involved, because this is obvious):

$WQTRUST * pqtrust(w) = \text{sum}\{r, DINC_REG, WQTFIRM(r) * pcgds(r)\};$

Then the change in price of the total portfolio of the regional household (pwqh) can be calculated easily as:

$WQHHLDR(r) * pwqh(r) = WQHFIRM(r) * pcgds(r) + WQHTRUST(r) * \text{sum}\{w, DINC_WORLD, pqtrust(w)\};$

Now we get at the more complicated part. The change in wealth of the regional household (wqh) equals the change in wealth as a consequence of revaluation of the portfolio plus savings:

$WQHHLDR(r) * wqh(r) = \{WQHHLDR(r) * pwqh(r) + SAVE(r) * 100 * \text{time} + STEPSIZE * SAVE(r) * (qsave(r) + psave(r))\};$

Savings are savings per year, so it has to be multiplied by the time variable. But there is also a change in the value of savings during the calculation step: SAVE(r)*(qsave(r)+psave(r)). This is the change in the yearly savings during the step of the calculation, so the effect on wealth depends on the length of the period under consideration, i.e. the length of the simulation period in years divided by the number of steps for the calculation of the simulation, called STEPSIZE. This is an essential part of the equation to determine the change of wealth in a

consistent manner. So, the basic idea is simple, but the implementation in the linear equation system is a little bit more difficult than you would expect at first thought.

4.4.2 Choice between domestic and international investment

We define as the available funds for reallocation the new funds, i.e. savings, and a part from the invested funds that may be reallocated, where we differentiate between the share of international and domestic investments that can be reallocated:

$$\begin{aligned} \text{FUNDSAV}(r) = & \text{SAVE}(r) \\ & + \text{INTAVAILSHR}(r) * \text{WQHTRUST}(r) \\ & + \text{DOMAVAILSHR}(r) * \text{WQH FIRM}(r) \end{aligned}$$

Part of this available fund is invested domestically, and the rest internationally. The share that is domestically invested is called DOMFUNDSHR. We calculate the initial value as:

Formula (initial) (all,r,DINC_REG)

$$\text{DOMFUNDSHR}(r) = (\text{DOMAVAILSHR}(r) * \text{WQH FIRM}(r) + \text{SAVE}(r) - \text{CWQHTRUST}(r)) / \text{FUNDSAV}(r);$$

When the regional rate of return equals the global rate of return, the shares of domestic and international investment remain the same, but if they differ, the percentage change of the domestic fund share is explained by the difference between the regional and the global average net rate of return capital, that is multiplied by its absolute value to get a faster adjustment of the fund shares when the difference between regional and global rates of return is bigger:

Equation DOMFUNDSHR1 (all,r,DINC_REG)

$$\text{p_domfundshr}(r) = \text{abs}(\text{NETRETCAP}(r) - \text{GNETRETCAP}) * \text{DFNDADJSPED}(r) * (\text{NETRETCAP}(r) - \text{GNETRETCAP}) * 100 * \text{time} + \text{fundconsist}(r);$$

The same line of reasoning is used for the percentage change in the international fund share:

Equation INTFUNDSHR1 (all,r,DINC_REG)

$$\text{p_intfundshr}(r) = \text{abs}(\text{NETRETCAP}(r) - \text{GNETRETCAP}) * \text{DFNDADJSPED}(r) * (\text{GNETRETCAP} - \text{NETRETCAP}(r)) * 100 * \text{time} + \text{fundconsist}(r);$$

in domestic plus international fund share should be zero, an equation FUNDCONSOST1 is added that guarantees this consistency by using the variable fundconsist as a shifter in the domestic and international fund share equations:

Equation FUNDCONSIST1 (all,r,DINC_REG)

$$\text{DOMFUNDSHR}(r) * \text{p_domfundshr}(r) + \text{INTFUNDSHR}(r) * \text{p_intfundshr}(r) = 0;$$

NETRETCAP is the domestic return on capital and GNETRETCAP is the global return on capital invested in the international trust. The time variable is just the length in years of one step in the iteration, while the factor 100 is introduced to create percentages. The net return on capital can be easily calculated as:

$$\text{NETRETCAP}(r) = (\text{VOA}(\text{"capital"}, r) - \text{VDEP}(r)) / \text{VK}(r) + \text{RISKPREMIUM}(r);$$

Where the coefficient RISKPREMIUM may be used to require a higher normal return on capital in more risky countries.

After this relatively straightforward line of reasoning again a relatively complicated equation is needed to calculate the change in wealth invested in the international trust:

$$\begin{aligned} \text{WQHTRUST}(r) * (\text{wght}(r) - \text{sum}\{\text{w,DINC_WORLD,pqtrust}(\text{w})\}) = \\ (\text{INTFUNDSHR}(r) * [\text{FUNDSAV}(r) * 100 * \text{time} \\ + \text{SAVE}(r) * \text{STEPSIZE} * \text{qsave}(r) \\ + \text{FUNDSAV}(r) * \text{STEPSIZE} * \text{p_intfundshr}(r)] \\ - \text{INTAVAILSHR}(r) * \text{WQHTRUST}(r) * 100 * \text{time}); \end{aligned}$$

This calculates a value for the change in real wealth invested in the international trust (wght(r)-pqtrust). The first part is simply the international fund share multiplied by the funds that are available at the start of the step. The second part is the amount that is added during the period as a consequence of savings. The third part is what became available as a consequence of a change in the international fund share during the period. And finally there is

subtracted from this what has been taken away because it has been made available for reallocation (INTAVAILSHR*WQHTRUST).

4.4.3 Investment of the international trust

The change in investment in the international trust is determined, the investment in domestic firms can be easily calculated as a residual.

$$WQHFIRM(r) * wqhf(r) = WQHHLDR(r) * wqh(r) - WQHTRUST(r) * wqht(r);$$

In the same way also the total wealth in the international trust can be calculated:

$$WQTRUST * wqt(w) = \text{sum}\{s, DINC_REG, WQHTRUST(s) * wqht(s)\};$$

The allocation of the funds of the international trust over different regions follows the same principles as that of the allocation of funds over domestic and international:

$$p_gfundshr(r) = \text{abs}(\text{NETRETCAP}(r) - \text{GNETRETCAP}) * \text{GFNDADJSPED}(r) * (\text{NETRETCAP}(r) - \text{GNETRETCAP}) * 100 * \text{time} + \text{sum}\{w, DINC_WORLD, gfundshift(w)\};$$

$$\text{sum}\{r, DINC_REG, GFUNDSSHRR(r) * p_gfundshr(r)\} = 0 * gfundshift(w);$$

where the variable gfundshift is only added because otherwise the programming language GEMPACK would give an warning.

The change of wealth invested in different regions is again defined based on the fund shares, where the linear equation creates some extra complications by requiring that also changes during the calculation step are included:

$$\begin{aligned} WQTFIRM(r) * wqtf(r) - pcgds(r) = & \\ GFUNDSSHRR(r) * (GFUNDSAV * 100 * \text{time} & \\ + \text{sum}\{s, DINC_REG, INTFUNDSSHRR(s) * \text{SAVE}(s) & \\ * \text{STEPSIZE} * \text{qsave}(s) & \\ + \text{INTFUNDSSHRR}(s) * \text{FUNDSAV}(s) * \text{STEPSIZE} * p_intfundshr(s)\} & \\ + \text{GFUNDSAV} * \text{STEPSIZE} * p_gfundshr(r) & \\ + \text{GFUNDSAV} * \text{STEPSIZE} * \text{sum}\{w, DINC_WORLD, gfundshift_1(w)\} & \\ - \text{GAVAILSHRR}(r) * WQTFIRM(r) * 100 * \text{time} & \end{aligned}$$

The variable gfundshift_1 guarantees that all wealth is allocated somewhere, according to the following equation:

$$WQTRUST * wqt(w) = \text{sum}\{r, DINC_REG, WQTFIRM(r) * wqtf(r)\};$$

Now the change in wealth of the firm in region r is defined by the change in wealth invested by the regional household in the firm plus the change in wealth invested by the regional trust in the firm:¹

$$WQ_FIRM(r) * wq_f(r) = WQHFIRM(r) * wqhf(r) + WQTFIRM(r) * wqtf(r);$$

4.4.4 Capital stock and investment

Finally, the change in wealth of the firm determines the growth of the capital stock of the firm by deflating it by the change in the price of capital goods:

$$qk(r) = wq_f(r) - pcgds(r);$$

and total investment (qcgds) is determined also by the change in wealth (wq_f)²:

¹ In the model code there is a variable wq_fa, that is only used for some consistency checking, and forcing consistency if it wouldn't be realized. This improves the calculation efficiency of the model, but has no fundamental influence on the results.

$$\begin{aligned} \text{WQ_FIRM}(r) * [\text{wq_f}(r) - \text{pcgds}(r)] = & \text{NETINV}(r) * 100 * \text{time} \\ & + \text{STEPSIZE} * \text{NETINV}(r) * \text{pcgds}(r) \\ & + \text{STEPSIZE} * [\text{REGINV}(r) * \text{qcgds}(r) \\ & - \text{VDEP}(r) * \text{qk}(r)] \end{aligned}$$

The two equations together determine the relationship between investment and the change in the capital stock. In contrast with the static model, this change in capital endowments equals production of the capital goods industry. In the static model the change in end capital (ke) is determined by the growth of the capital stock through investment, but this is not used for the change in capital endowments, only to make predictions about expected changes in profitability. In the dynamic model the change in the production of capital goods (REGINV*qcgds) is determined by the change in wealth of the regional firm (WQ_FIRM(r) * wq_f(r)). Part of this change is determined by a change in the price of capital goods (pcgds), part by the net investment stream in the current period (made consistent with current prices through pcgds) and the rest of the wealth has to be determined by extra net investment (that is already changed because the depreciation changes). So, the essence of the dynamic investment model in MAGNET is that the production of capital goods is determined by the wealth allocation decisions of the regional households and the international trust.

4.5 Depreciation adjustment

In standard projections of growth of capital stock based on standard capital growth assumptions used in most projects where MAGNET is used, the stock of capital is growing much slower than would happen according to net investment in the model. This inconsistency is The background of this is that the depreciation rate in the GTAP database is relatively low, i.e. 4% of capital stock per year. This seems very low, because a lot of capital goods have much higher depreciation rates. For example, computers are depreciated in 3 to 5 years. The depreciation rate that is consistent with normal growth of capital stock is a little bit more than 6% per year. For this reason, we replace the depreciation rate in the GTAP database of 4% with a depreciation rate of 6%.³

The consequence of the data adjustment procedure is that there are more regions than in the original GTAP database with negative savings, because savings is defined as the gross earnings on capital minus depreciation. This may generate problems in welfare calculations, because implicitly it is assumed that the starting utility of savings is set at positive number, while this should be a negative number in case savings are negative. For the further behavior of the model it doesn't matter, although the standard behavior of the regional demand function implies that negative savings tend to increase with rising income. For this reason, the savings are exogenously reduced in regions with negative savings in the starting year.

² Again in the model qcgdsa is defined with an equation that checks if this equals qcgds with a slack variable walrasshift that is normally zero.

³ We do this by the following formula in the database adjustment procedure in the database adjustment program AddAndmodifyData, routine Depreciation6perc:

Formula (all,i,CGDS_COMM) (all,j,DENDW_COMM) (all,r,DREG)
 MSAM(i,j,r)=1.5*MSAM(i,j,r);

4.6 Determining model parameters and initial values

For the initialization of the investment module the initial stocks of wealth have to be determined as well as the changes in wealth over time. The source that could be used is the updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007).

The adjustment parameters and the shares of funds that are available are just set. Although this may not seem to be very satisfactory, the behavior with the chosen set of parameters is satisfactory. Future research to improve the empirical underpinning of the parameters may be valuable.

At this moment the aggregation procedure is not completely satisfactory. Because there is no information on bilateral wealth, you don't know how much wealth should be skipped if regions are aggregated together. At this moment wealth is just added, implying an over-estimate of gross external wealth positions for aggregated regions. It doesn't influence the net positions of regions, and in that sense is not fundamental for model outcomes.

4.7 Empirical foundation and theoretical properties of the dynamic model

At this moment there is no empirical foundation for the dynamics, but neither is this available in the other versions of the GTAP model. The dynamic module provides opportunities for empirical estimation of the adjustment parameters, while empirical information about the international capital flows may be used to initialize the flows.

The long term behavior of the equation system guarantees equal rates of return in all countries in the long run. This can be easily verified by running the model without shocks for a long period of time. The dynamics shows also that there is a tendency that the capital stock tends to grow with the growth rate of GDP as can be shown by changing the growth rate of a country and investigating the development of the growth rate of capital stock over time.

Next to the advantage of having international capital in, the closure improves stability of the model. This required the adjustment towards relative returns to be quadratic; with a linear function the adjustment was too slow to guarantee stability. This module in that sense replaces the so-called Dixon adjustment that is sometimes used to increase the stability of the standard GTAP closures in MAGNET. Even if the data are not reliable, the mechanism is that strong that it improves stability of the model and certainly will not have a worse behavior in the long term than the standard closures of GTAP. Furthermore, it provides direct insight in the capital flows that are implicit in standard GTAP analyses.

4.8 Conclusion

The Indian economy is opening up towards international trade and capital flows. For this reason it may be useful to introduce these capital flows explicitly in the model.

The dynamics of capital inflows and outflows is derived from the current investment streams. There are two main decisions modeled. First, the decision to invest available domestic funds either domestically or internationally. The current distribution of these investment streams is taken as a starting point, where the relative profitability of the two types of investment redirects those investment streams gradually. It is assumed that a fixed part of current international and domestic wealth can be reallocated, while also new savings can be allocated.

All international investments are assembled together in an international trust, and this trust decides about adjustment of the investment streams over different regional allocations based on the past investment flows and relative profitability (including risk premiums). The sum of domestic and international capital streams determines funds available for investment, and therefore the change in capital stock and production of the capital goods sector.

The basic idea of the international capital allocation is that flows in the past are adjusted gradually according to relative profitability. We start with the definition of the funds that are available for reallocation. We define the available funds for reallocation, i.e. the new funds generated by savings, and a part from the currently invested funds that may be reallocated.

The change in wealth of the household is determined by revaluation, savings at the start of the period and the changed savings during the period. Based on the calculated domestic fund shares, the change in wealth invested by the regional household in the domestic firm can be calculated. The wealth not invested in the international trust is by definition invested in the domestic firm.

The investment of the international trust in the different countries is modeled according to the same principles. The funds available for international reallocation are composed of a part of invested the money that is reconsidered for reallocation, plus the money that is added by the regional households to the stock of investment. Based on information about the relative profitability of investment in countries, the shares of the investment flows adjust.

The sum of the wealth invested by the regional household and the international trust determines the wealth change in the region. This wealth change (in constant prices) in the region determines the change in capital endowments in the dynamic model, something that was exogenous in the static model.

In contrast with the static model, the change in capital stock equals production of the capital goods industry. In the static model the change in end capital is determined by the growth of the capital stock through investment, but this is not used for the change in capital endowments, only to make predictions about expected changes in profitability. In the dynamic model the change in the production of capital goods is determined by the change in wealth of the regional firm. Part of this change is determined by a change in the price of capital goods, part by the net investment stream in the current period and the rest of the wealth has to be determined by extra net investment (that is already changed because the depreciation changes). So, the essence of the dynamic investment model in MAGNET is that the production of capital goods is determined by the wealth allocation decisions of the regional households and the international trust.

At this moment there is no empirical foundation for the dynamics, but neither is the case in the GTAP-DYN model as developed at Purdue University. The MAGNET implementation provides opportunities for empirical estimation of the adjustment parameters, while empirical information about the international capital flows may be used to initialize the flows.

The long term behavior of the equation system guarantees equal returns of return in all countries in the long run. This can be easily verified by running the model without shocks for a long period of time.

One crucial variable that determines the worldwide economic growth of capital stock is the depreciation rate. This is initialized at 4% in the GTAP database, where this seems to be relatively low from a theoretical point of view, because a lot of capital goods have a much higher depreciation rate. Also empirically, the growth of capital stock generated with the depreciation rate of 4% is too high compared with the projections we make normally. For this reason, for TAPSIM a depreciation rate of 6% has been implemented.

In summary an intuitive dynamics of investment behavior have been implemented in the MAGNET model that is based on two basic decisions: the decision to invest funds

domestically or internationally, and the decision how to allocate international investment funds over different regions in the world. Available funds for investment in a region are determined by domestic availability of savings and attractiveness of the region for international investors.

The line of reasoning in the international capital allocation is straightforward, but the implementation requires a lot of tricks to guarantee stability and consistency. The advantage of this approach is the ease of interpretation of the mechanisms involved. In the current setting changes in the international capital flows are determined by relative profitability of investment. This does not guarantee that during the process of adjustment there is some overshooting. Although the dynamics that is generated does not seem too bad, it may be worthwhile to incorporate also a mechanism where the international investors think about the long term steady state.

5 Biofuels and agricultural production

5.1 Introduction

In order to run biofuel scenarios for TAPSIM the biofuels had to be included into MAGNET. Biofuel production competes with food production and may generate intensification. Biofuel production generates also by-products that can be used for animal feed and may also use feedstock that otherwise would have been used as animal feed, of which molasses for ethanol is an example. For this reason, it is important to make animal feeding and its substitution possibilities explicit in the model, and also to make the use of fertilizer explicit in the model. This requires that a number of sectors and commodities had to be introduced in the database used for the model, while the substitution possibilities between different types of animal feed and between land use and intensification had to be included in the model. And obviously, also the technologies and sectors relevant for biofuels had to be included.

In this chapter we first discuss the introduction of new sectors and the methods used to include them in the database. Then we discuss the design of a production structure in the model that allows for all important substitution possibilities.

5.2 Creating new sectors

5.2.1 Introduction

Including biofuels requires that the feedstock for biofuels are in the model. For India this is a specific one, i.e. molasses, a by-product of sugar. For this reason the molasses sector had to be split from the sugar sector. Second, the by-products of biofuel production must be included the database. For maize and wheat ethanol this is DDGs, for biodiesel this is oilcake that is a byproduct of the vegetable oil sector. Third, the feedstock sectors should not include too many irrelevant commodities. For example, the vegetable oil sector in the GTAP database produces also a large number of refined products, implying that the average price is much too high as an input for the biodiesel sector. For this reason, a crude vegetable oil sector has been defined that has only a small value added included, while the refined vegetable oil sector uses this crude vegetable oil as an input and has a lot of other inputs. Fourth, the biofuel by-product must be used in the correct manner, i.e. be a substitute of the right alternative products. Because most byproducts are used in the feed sector, this requires that animal feed must be modelled correctly. One problem with this is that the in the GTAP database animal feed is only a small part of a large sector called “other feed and food”, which includes for example also canned fish. For this reason the relevant part of this sector had to be split off from this sector and included as the feed sector. Finally, one of the issues discussed in relation with biofuels is to what extent increase in biofuel production stimulates intensification. The main ingredient of intensification is the increase in the use of fertilizer. In the GTAP database fertilizer is included in the chemical sector. For this reason, the fertilizer sector had to be split from the chemical sector. In summary, a lot of sectors had to be added and split in order to get a model that is suitable for the analysis of biofuel policies.

During the TAPSIM project the technology of splitting sectors in MAGNET has been developed gradually. In order to discuss the methods used, we start with the most simple methods used for creating molasses as a separate commodity and end with the most complicated procedures developed to create the biofuel sectors.

5.2.2 Splitting the feed and fertilizer sector

The feed and fertilizer sector are sectors that have been split in the most simple manner possible, i.e. by just using information in the GTAP database. The fertilizer sector is split from the chemical sector, assuming that all deliveries from the chemical sector to the crops sector involve deliveries of the fertilizer sector. This implies that we include pesticides in the fertilizer sector; both imply that production per hectare can be increased. The basic method of splitting is as follows. First, deliveries to the crop sectors by the chemical sector can be split into imported and domestic deliveries. The imported deliveries imply extra demand for the fertilizer sector in other regions, and the imports are split over different regions according to the import share of the chemical sector. For the supplying regions the exports plus the domestic deliveries of the fertilizer sector determine total production. This total production is split from the chemical sector producing assuming that the cost structure is the same as the average cost structure in the chemical sector. Taxes are split over the fertilizer and chemical sector consistent with this approach. This simple method is by definition consistent and doesn't influence other sectors, but it is obvious that no specific information on the cost structure or trade of the fertilizer sector is taken into consideration. For a rough modelling of fertilizer this is sufficient, but for more refined analyses it would be beneficial if more specific information on cost and trade could be taken into consideration.

The animal feed sector in the GTAP database is part of a larger sector, called "other feed and food" (ofd). For the animal feed sector it is assumed that it delivers to the animal production sectors, so the imported and domestic deliveries from the ofd sector are assumed to be animal feed. In contrast with the split of the fertilizer sector the cost structure of the animal feed sector is different from that in the original sector in that organic components are about 60% of the total cost of animal feed, while that is less than 40% in the original ofd sector. This guarantees that the energy and protein content of the product produced by the new feed sector is higher than in the original ofd sector, but it is still relatively low compared with the oil seed sector. To improve on this in the long run it would be beneficial to include empirical information on the cost structure of the animal feed sector as well as empirical information on the protein and energy content of the product produced. For the moment this is a first approximation that at least improves the substitution between the animal feed sector and other ingredients of the sector.

In summary, a start has been made to implement fertilizer use and animal feed in a better way in the MAGNET model. The current method is very rough but much better than doing nothing at all. The next step is to put much more empirical information on both sectors in the database.

5.2.3 Splitting molasses from the sugar sector

Molasses is a byproduct of sugar production and therefore does not require the creation of a new sector, only a new commodity. So, the sugar industry produces two commodities: sugar and molasses. Molasses is normally used as animal feed. Sometimes molasses is directly delivered to the animal sectors, and then it is plausible that all of it is animal feed. However, a lot of animal feed is delivered indirectly through an animal feed sector. Regrettably, this animal feed is not separated in the GTAP database, i.e. it is included in a sector called "other feed and food" (ofd) that includes also products that use sugar. As described above, we did split the animal feed sector from the ofd sector, and assume in this procedure that this split is correct. Therefore, we assume that all deliveries of the sugar sector to the animal feed sector and the animal sectors equals total production of molasses. This implies that on a worldwide base about 10% of the production value of the sugar sector is sold as molasses. This is obviously less than is the case, but for the current analysis it is sufficient to have the molasses

in. For the future explicit information on the use of molasses should be included in the database.

5.2.4 Splitting a crude vegetable oil and oilcake sector

Biodiesel is one of the two biofuels, and production of this product requires vegetable oil. Regretfully, the vegetable oil sector in the GTAP database includes a lot of refined products and therefore produces vegetable that is much too expensive to use for biodiesel production. For this reason, following Taheripour and ... (200?) we split a crude vegetable oil sector from the vegetable oil sector. This crude vegetable oil sector uses oilseeds and some other inputs to process the feedstock towards vegetable oil and oilcake. The value of these other inputs, including value added, is targeted at 25% of the cost price, while it is more than 65% in the original vegetable oil sector. What is left over of the sector remains the vegetable oil sector, and this sector uses crude vegetable oil as an input as far as internal deliveries within the original vegetable oil sector are involved. What is left over of crude vegetable oil is distributed over all demand for the vegetable oil sector. The crude vegetable oil is also the input for the biodiesel sector, but that is calculated when biofuels are initialized.

In producing vegetable oil oilcake is produced as a by-product. It is assumed that the deliveries of the GTAP vegetable oil sector to the livestock and feed sectors is animal feed, where a maximum is set at 15% of the production value of the vegetable oil sector (except for the palm oil users Malaysia and Indonesia that have 2% by-products). Also the demand for imported oilcakes is taken into account, something that requires a relatively complicated procedure to match exports of oil cake with import demand for oil cake. The potential export of oilcake is determined as the production of oilcake minus what is used domestically. An iterative procedure has been developed that starts with the assumption that oilcake trade follows the trade in the original vegetable oil sector but limits exports of regions that don't supply enough oilcake to be exported, where in first instance a fraction from the potential exports is taken as a maximum. This implies that not all imports are satisfied, and these are allocated according to the same key, gradually increasing the fraction of exports that is allowed to be exported. In this manner the trade flows of products of the vegetable oil sector influence the trade flows of oilcakes, but in the end all regions import oilcake from those regions that have an excess supply of oilcake production.

The crude vegetable has the same problem to be solved as the oilcake sector. So, also for this sector bilateral trade is matched through an iterative procedure starting from the trade flows in the original vegetable oil sector and ending in a consistency between excess supply of crude vegetable oil and exports. Trade of refined vegetable oil products is just the residual of the trade of the original vegetable oil sector minus the trade of the oilcake and crude vegetable oil sectors.

In summary, the GTAP vegetable oil sector is split over crude vegetable oil, refined vegetable oil and oilcake production through a procedure that takes into account which users use the different products, the supply and demand conditions in different regions, and keeps the sum of the three new commodities equal to the old vegetable oil sector in GTAP. So, if you aggregate the newly created sectors together you will get exactly the old vegetable oil sector in GTAP.

5.2.5 Creating biofuel sectors

The biofuel sectors are the most complicated sectors to introduce, because they don't seem to be included in the GTAP database in the right way, while we would like to have the cost structure of the sector more or less right. Even formally the ethanol sector is part of the chemical sector with respect to production, while it is part of the beverages and tobacco sector for trade, without having sufficient deliveries from the chemical sector to the

beverages and tobacco sector to make this possible. Furthermore the cost structures of biofuel production require too much of some inputs to be taken from the chemical sector. For this reason, we have decided not to take the biofuel production from a specific sector, but take a little bit away from a large number of sectors. This procedure has the advantage that the database is only a little bit disturbed at a large number of places instead of having a large disturbance in one specific sector.

The basic method of the introduction of different biofuel sectors is as follows. First, a cost structure for each type of biofuel is read, where the type of biofuel is defined by its type of feedstock. At this moment we assume that technologies per feedstock are the same for each region. For each feedstock also the quantity of feedstock in wet tonnes is read, where this quantity is multiplied by prices for the feedstock as supplied by FAO. This makes the cost structure region specific, but only for the feedstock cost. Then the mix of feedstock that is used is gathered from different information sources and determines the average cost structure per litre of ethanol or biodiesel. Based on this the cost price per litre biofuel can be determined.

The next step is to calculate the amount of biofuel produced. The volumes of biofuel production are taken for the International Energy Agency (IEA), and these volumes are multiplied by the cost per unit of biofuel to get the total inputs needed to produce the biofuels.

When these calculations are finished, the needed inputs are taken from other sectors in the economy. The set of sectors from which they can be taken is defined by the user, and may be specific for the sector that at hand. A general routine then calculates the total amount of each input available in all the sectors from which the user allows them to take it from. For each sector in this set the same percentage of the input is taken. In this way the disturbance generated by the introduction of the new sector can be relatively limited as long as the total availability of the required inputs in the sectors where it is taken from is much higher than in what is needed for the biofuels. After calculation the user can see with which percentage the inputs are changed in the different sectors, while the user can define a maximum percentage that is taken out. In the latter case, the user can also see how much of the required inputs can not be allocated, implying a in most cases small reduction in total biofuel production and a small disturbance of the calculated cost structure. It is obvious that the procedure is handy, but requires careful checking when it is used.

After the inputs are taken out from the other sectors, the inputs are given to the biofuel sectors, again have the same share of wanted inputs for all sectors calculated in the same routine. After production value of the biogasoline sector is determined, the output is split in biogasoline and its byproduct DDGs. Based on the amount of relevant inputs used (i.e. wheat and maize) the production value of DDGs is determined, and the cost price of biogasoline is the difference between the total cost of production per unit of output minus the revenues that are generated by the byproduct. This determines the cost structure and total production of the biofuel sectors.

When biofuel production is calculated, also trade must be included in the database. Trade is also taken from IEA. While IEA does supply only imports and exports and not bilateral trade, bilateral trade is calculated assuming that each region exports to all the regions in the world according to the share in global biofuel imports. When bilateral trade data are available, this can be potentially implemented in the trade pattern. In order to create trade for biofuels, bilateral trade flows of other commodities must be reduced. Again a general procedure has been developed to this, where the percentage reduction of bilateral trade for each sector (that is allowed to be adjusted by the user) is the same. Import tariffs are made consistent with the tariff data as available in the database, i.e. as supplied by the TASTE program (see section 4.3).

Finally the flows of biofuel and byproducts must be supplied to the relevant sectors. For the biofuels this is the petroleum sector, where the biofuel production is just added to the total production. For the delivery of DDGs to the livestock sector the extra supply of animal feed is taken from the feed sector supply.

A general routine at the end makes the SAM consistent. The most important part is the consumption side, where the extra petroleum production is supplied to the consumer. This extra consumption of petroleum is compensated by reduced consumption for the sectors from which inputs were taken for the production of biofuels.

When all adjustments are made, a number of indicators is made that can be checked by the user. One of these indicators is if some consumption or inputs has changed significantly. Again, all the routines developed help a lot in creating a good database, but the wisdom of the user is required to check if the procedures do not generate disturbances in the database that are too big.

5.2.6 Conclusion

A large number of sectors has been defined and filled for the TAPSIM simulations. In order to do this a large number of standard routines have been developed that makes it easier to introduce new sectors in the future and make the calculations more reliable. The weak point in these developments is still the empirical underpinning of the data used.

5.3 Production structure

5.3.1 Introduction

The MAGNET model has a flexible CES nesting structure for production. Different sectors may have a different nesting structure. For TAPSIM the production structure is very simple model. Substitution between capital and energy (i.e. petroleum, gas and electricity) is possible, where the combination of capital substitute with labour and natural resources. All these non-land components substitute with land. All other inputs have fixed technological coefficients, i.e. a Leontief production structure.

The flexible production structure creates the opportunity to change the substitution possibilities between inputs when a specific policy scenario at hand requires this. For a sound agricultural and biofuel policy analysis some of these substitution possibilities are essential. First, in order to have a possibility to intensify production of crops, fertilizer must not only included as an input, but must have a substitution possibility between fertilizer and land, i.e. when you apply more fertilizer less land per kg of crop is required.

5.3.2 Standard production structure

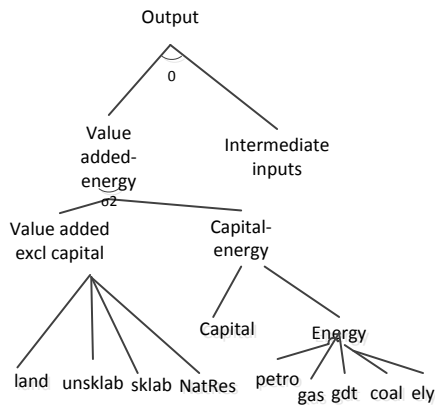


Figure 5-1 Standard CES production structure

For most sectors (all that are not described below) a production structure derived from GTAP-E, i.e. the energy variant from GTAP, is used. It is more simple than in GTAP-E because we assume that only processed types of energy are used in these sectors. At the top value added and all intermediate inputs have fixed technical coefficients. Within value added there is a non-capital value added nest and a capital-energy nest. Within the capital-energy nest capital and energy can be substituted. Within the energy nest different types of energy can be substituted. The elasticity of substitution between capital and energy is set at 0.5, and between the different types of energy at 1.0, following GTAP-E. For the non-capital value added nest the standard GTAP substitution elasticities are used.

5.3.3 Petroleum sector

The petroleum sector produces petroleum products from fossil fuels and blends biogasoline and biodiesel with these petroleum products. For this reason, the first CES level of blending is between biofuels and fossil fuels (figure 5.2). In modelling biofuels we force the biofuel share in petroleum production exogenously, and we don't want that the blending of the biofuels influence the energy content or relative cost of biofuels. Therefore the elasticity of substitution fossil and biofuel is set very high at 50, while substitution possibilities between biodiesel and biogasoline (ethanol) is relatively small and set at 3. The production structure of the fossil petroleum sector is the standard GTAP configuration: a CES nest for value added, and fixed coefficients for the intermediate inputs.

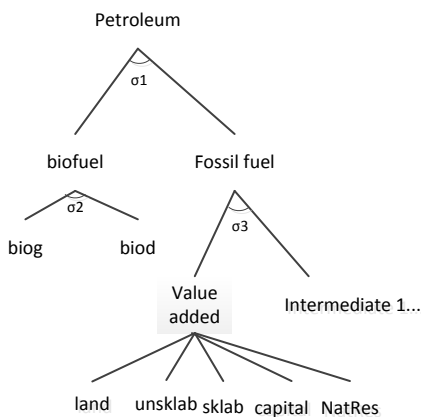


Figure 5-2 The CES production structure of the petroleum sector

5.3.4 Biogasoline and biodiesel sector

The ethanol and biodiesel sector convert biofuel feedstock into biofuel. They have the standard production structure with one extra nest, the feedstock nest. At this moment the feedstock nest for biodiesel has only one input, vegetable oil; so no substitution is possible. For biogasoline the substitution possibilities are much larger, as figure 5.3 shows. Figure 5.3 focuses on the new nest and leaves out the part below the value-added energy nest. The feedstock is a fixed input. Within the feedstock input substitution is possible between sugar based feedstock and other feedstock with an elasticity of substitution of 5. Much easier is it to substitute between the feedstock categories, with an elasticity of substitution of 50 between the different types of sugar based feedstock, and an elasticity of substitution of 20 between the other feedstock. These numbers are more or less chosen ad hoc, based on plausibility of outcomes.

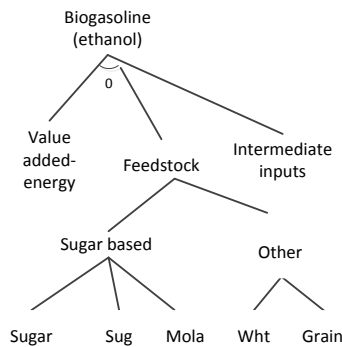


Figure 5-3 Biogasoline sector

5.3.5 Crop sectors

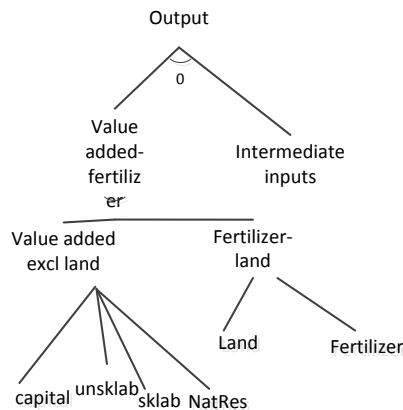


Figure 5-4 Crop sectors

The main characteristic of the crop sector is the use of land with a possibility of intensification by fertilizer use. Figure 5.4 shows the production structure of these sectors. The basis is standard GTAP, but the value added nest is split into a land-fertilizer nest and a standard value added nest that excludes land. Within the fertilizer-land nest, substitution between land and fertilizer is possible. We use for the substitution between fertilizer-land and value added we use a substitution elasticity of 0.1, the standard MAGNET value, and for the substitution between land and fertilizer we use 0.8.

5.3.6 Animal sectors

The animal sectors have a similar structure as the crop sectors, but instead of having a possibility to substitute between land and fertilizer intensification is modelled as the increase of use of feed that is bought on the market (figure 5.5). So, there is a substitution possibility between animal feed and land (with an elasticity of substitution of 0.6), symbolizing the substitution between concentrates and roughage. Within the animal feed nest there is a possibility to substitute between high energy feed and high protein feed with an elasticity of substitution of 2, while within these feed categories there is an elasticity of substitution of 20, i.e. a very easy substitution. This last is important, because if biofuel production increase the supply of for example DDGs and oilcake and reduces the supply of molasses as animal feed, it is important that the substitution is relatively easy.

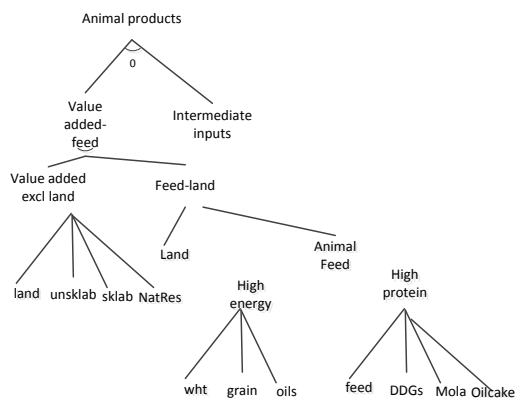


Figure 5-5 Animal sectors

5.3.7 Animal feed sector

As discussed before, GTAP has a large sector of *ofd* that includes animal feed. This animal feed sector, mainly producing concentrates, blends a number of ingredients depending on relative prices. For this reason, also this sector has a separate nesting structure. Because the principle is not fundamentally different from the animal sectors, it just uses the structure of the animal sectors.

5.3.8 Conclusion

For the simulation in TAPSIM an advanced production structure has been developed that takes into account the technologies for biofuel blending with fossil fuels, intensification in crops and livestock, feed blending for concentrate animal feed, and a substitution possibility for different feedstock of biofuel production. Almost all sectors have the possibility to substitute between capital and energy and different types of energy. So, the basic principles are in the model, although it may be worthwhile to refine the empirical foundation of the substitution elasticities used in the model.

5.4 Conclusion

In the TAPSIM project important steps are made to improve the modelling of agricultural, animal feeding and biofuels. The basic mechanisms are in and standard procedures have been developed to make it relatively easy to include new sectors. This makes it possible to give rough ideas in simulations on the mechanisms that determine the dynamics of agricultural and biofuel production. When better data on fertilizer use, animal feeding and biofuel production

possibilities come available the quality of the analysis can be further improved. The main of achievement of the project for this part of the model development is that the mechanisms are brought in and most relevant sectors are included in a stylized manner. Perhaps the main sector that is lacking and potentially very relevant for India is the irrigation sector.

6 Trade agreements and international trade

6.1 Introduction

During the development of the model for TAPSIM it became obvious that with the 2001 data that were used in first instance trade for some commodities was so small that it would never reach a significant size with the standard Armington substitution elasticities used in the model. According to the Armington hypotheses a percentage change in import share depends on the percentage change in relative prices. If the original import share is extremely small or even zero, extremely large changes in relative prices are required to change imports significantly. For this reason, it seemed useful to increase the standard Armington import elasticities if the import share was very low and the competitive position tended to improve. When the 2007 database became available this became much less important, while the flexible Armington approach above implies that also for commodities that are not competitive the import shares may increase. To solve the last issue much more information on competitiveness was required than was available. For this reason, we have decided not to use the flexible Armington approach in the end. However, in the long term it will become essential to have such an approach in, and therefore we include a short discussion on this approach in the first part of this chapter.

Second, in analysing trade agreements in MAGNET changes in bound tariffs were standardly applied to applied tariffs. This is not very important if there is not much water in the tariffs, but when there is a large difference between bound and applied tariffs it generates effects that are much too high. This is the case for EU-Indian trade. For this reason a system has been developed within MAGNET to include information on the difference between applied and bound tariffs in calculating the effects of trade agreements. This is discussed in the second part of this chapter.

6.2 Increased flexibility in Armington import elasticities

When the first baseline projections for Indian were made, Indian agricultural prices increased a lot compared with international prices without having much influence on the imports of these commodities. This was not very plausible. For a lot of agricultural sectors India had a very low level of imports and exports. If the economy grows further and if trade is freed up further, it can be expected that trade will increase. The standard Armington approach used in MAGNET is not able to model this type of dynamics, because with relatively low Armington elasticities as used in the standard GTAP model trade will never become significant when the initial flows are zero or very small. On the other hand, increasing those elasticities in general is very dangerous, because it will also distort trade in the rest of the world. For this reason, two important adjustments have been made to the Armington approach in MAGNET.

First, the Armington elasticities have been made dependent on the current share of imports in total demand. When the import share is very small, the elasticities are high, and the elasticities decrease when the share increases. If you would do this in a symmetric way, as is the standard approach, this would imply that with decreasing Indian prices the import share would even become smaller than it already was. For this reason the increase in Armington is applied in an asymmetric manner: if prices in India increase, the Armington elasticities are high, if prices in India decrease, the Armington elasticities are low. This required some tricks in programming, because the model doesn't know directly what the direction of a change is. For this reason the change in the first calculation step is used to check what the direction of change is, and in all calculation steps afterwards the change of the step before is used to

determine if the Armington elasticity has to be increased or not. In this way, import elasticities for trade can rise significantly when import shares are small, while it reacts in a normal way when import shares rise to more normal levels or when relative prices develop in such a manner that import share would decrease further.

Second, also on the demand side a small share has to be solved. When the share of imports of Indian products by other countries is very low, imports from India will never rise. As a consequence, India will not be able to increase its exports of commodities that have a small share in imports of other countries. For this reason, a nested Armington structure has been designed, where Indian commodities are substituted with all other commodities, with a different elasticity from the elasticities between imports out of the other countries. The elasticity of substitution between imports from India and imports from elsewhere has been made dynamic in the same way as the elasticity between imported and domestic products in India has been made dynamic. With small shares of imported commodities from India the elasticity is high, and with normal shares it remains the same.

In summary, for imports by India the Armington elasticities can be increased to such levels that when Indian prices become much higher than international prices the share of imports can increase through very high Armington elasticities. If Indian production becomes much more competitive on the world market, a nested Armington structure for imports of other countries creates the possibility to increase the small shares of India in their imports by putting higher import elasticities for Indian commodities. Although this approach seems very promising, lack of data on competitiveness and the use of a more recent GTAP database has led to the decision not to use this approach in the current simulations.

6.3 Use of 6 digit tariff data in an aggregated model

When new countries or sectors are introduced, it is important to have the tariff data included in the database. Furthermore, for calculation of free trade agreements in scenario's it is important to have both the bound and applied tariff data available. For both reason 6 digit tariff data have been included in the MAGNET database.

The 6 digit import tariff data are delivered by the program TASTE (Horridge and Laborde, 2008) and includes 6 digit bound and applied tariff data as well as trade flows to weight the tariffs. For each GTAP commodity there is a file that includes all the data. In order to make it possible to handle the data in a more general manner, these data are first integrated into one file with for each data type a specific header. Redundant information that is automatically generated by the TASTE tool is filtered out.

The next step is to process the data for further use. As far as the data are used to adjust import tariffs in the database, they are aggregated to a higher aggregation level, because for implementing tariffs in the database only applied tariffs are relevant. Procedures have been developed to integrate these tariff data in the database.

For TAPSIM scenarios based on bound tariffs had to be implemented, and for this reason the tariffs are kept at their lowest aggregation level. A procedure has been developed to calculate the applied tariffs of given bound tariffs rates: the applied tariffs are only reduced if the applied tariffs are higher than the bound tariffs. All tariffs are aggregated by using bilateral trade flows as weights. Finally the percentage changes in tariffs are calculated based on the average applied tariff rate after a trade agreement and the average applied tariff before the trade agreement. In this manner shocks on applied tariffs can be calculated in an easy manner.

6.4 Conclusion

In the MAGNET model an approach with asymmetric import share dependent import elasticities and the possibility for a simple nested structure of Armington elasticities has been included. Regretfully, the information on cost competitiveness was insufficient to apply the approach in a plausible manner, while luckily the introduction of a more recent GTAP database for TAPSIM made the need of this approach less urgent.

For analysing trade agreements with India the difference between applied and bound tariffs is crucial because there is a lot of water in the tariffs. The implemented system to calculate the right shocks on applied tariffs for agreements based on bound tariffs has been successfully implemented and will be applied in the scenarios about trade agreements.

7 Baseline design

7.1 Introduction

A baseline provides a reference scenario for all the other scenarios. It is meant to be an indication of what may happen, but is certainly not meant as a prediction of the future. For this reason sometimes a number of reference scenarios is used, but this complicates analyses a lot. For this reason, we develop a baseline of the world economy based on GDP and population projections from reliable outside sources like the United Nations and the OECD. The combination of these assumptions and the logic and

7.2 The exogenous projections

7.2.1 USDA projections of population and GDP

The MAGNET model requires population and GDP projections for calibration of the baseline. Although a lot of projections are available, most are not at the low and flexible aggregation level that we need in the MAGNET model. The USDA baseline projections are an exception on this. When comparing the USDA projections with for example OECD projections, they seem to be very similar. For this reason, we have chosen for the USDA projections as the starting point for our baseline.

The USDA published population and GDP projections till 2030 (<http://www.ers.usda.gov/Data/Macroeconomics/#BaselineMacroTables>). Their population projections are based on detailed international projections from the US Census Bureau ([Census Bureau International Population Database](http://www.census.gov/ipc/www/idb/estandproj.php), to be found in <http://www.census.gov/ipc/www/idb/estandproj.php>). The GDP series starts with recent GDP series derived from the latest edition of the World Bank's *World Development Indicators* and is filled in using other data sources such as Oxford Economic Forecasting, Global Insight, Project Link, and the International Monetary Fund's *International Financial Statistics*. Conversion to dollars is based on a fixed exchange rates of a base year.

The advantage of using the USDA series is that they are available at a low aggregation level, i.e. 190 countries and 34 regions of the world, are consistent and easily accessible.

Based on the USDA population projections and the GDP projections it is assumed that labor supply follows population. In normal MAGNET projections, it is assumed that capital stock growth follows GDP, but with the dynamic model growth of capital stock is endogenous. The stylized fact that capital stock growth follows GDP could be a point of reference to test the behavior of the international investment module developed for TAPSIM This last assumption is consistent with the stylized facts of economic growth, one of which is that the capital-output ratio is roughly constant over time. For natural resource growth it is assumed that it is 25% of GDP growth. Available land is based on information from the IMAGE model that is derived from FAO statistics in combination with a small part of technological change that depends on the average technological change.

For India specific labor supply projections are used, based on the assumptions in the national CGE of India. For the period 2010-2015 labor supply grows with 8.2%, for the period 2015-2020 with 6.5%. Then it decreases till 4.7% for 2020-2025 and 3.9% for 2025-2030.

7.2.2 FAO/PBL land productivity projections

Land productivity projections are based on FAO projections till 2030 as used in the study *World Agriculture: Towards 2015/2030 - An FAO Perspective* (Bruinsma, 2003). These projections are made consistent with the IMAGE land use database, and include adjustments for the quality of land that is used consistent with the IMAGE land allocation and climate model. These land productivity projections are relatively low and don't depend on the development of GDP per capita. For this reason, we have also added a component that depends on GDP per capita.

7.3 Technological change

In the MAGNET model technological change is modelled as a combination of technological change in all inputs and outputs in all sectors. In practice a regional technological change is calibrated based on GDP projections and a coefficient that distributes this regional technological change over different sectors and production factors. In the standard model the relative development of sectors is based on a study of Kets and Lejour (200?), that analyses the historical development of technological change in different sectors. The study uses data till 1990, and comes with a technological change that is much faster in agriculture than in other sectors, implying a decrease in real agricultural prices. However, current predictions of most representative institutions are a stabilization or slight increase of agricultural prices as a consequence of much less investment in agricultural technological improvements, the increasing scarcity of water, land and other resources, and the increasing difficulty to increase productivity further when the most important improvements of agricultural productivity have been implemented.

As a consequence, the distribution and size of productivity increases had to be adjusted. Based on experiments accomplished for the OECD Environmental Outlook scenarios and experiments in TAPSIM with respect to slower agricultural productivity, some adjustments to the technology distribution coefficients have been made, generating more or less stable real agricultural prices over time.

Technological change has been adjusted with productivity in primary agriculture growing 1.3 times as fast as in services, and productivity in industry growing 2.6 times as fast. This is consistent with more pessimistic views about the future of agricultural productivity as represented by predictions of stable or even rising real agricultural prices in the future. The technology is assumed to be mainly labour saving, with land productivity growing with the old FAO projections plus 30% of the increase in labour productivity. Capital productivity is assumed to grow with about 1/7 of labour productivity, natural resource productivity grows with 30% of labour productivity growth, while technological change for intermediate inputs is set at 10% of labour productivity growth.

The adjustments of the parameters is relatively ad hoc, and based on evaluation of simulation outcomes and some a priori assumptions, for example that change in intermediate input saving technology is not very big and that intermediate input saving technological change make the results depending on the aggregation level of the model. Compared with technology assumptions in other models, the assumptions in TAPSIM are already well-developed: in most baseline projections it is simply assumed that technological change is only applied to value added, and has the same rate for all production factors, while it is also exceptional that a difference in technological change is made between difference sectors.

7.4 Dynamic consumption elasticities

In most CGE models income elasticities of consumption are fixed over time. This is OK when income per capita is not changing a lot during the simulation period, but is not very applicable to a fast growing economy like the Indian one. Therefore a procedure has been developed to adjust the consumption function in the GTAP model towards a function with dynamic income elasticities.

The MAGNET model uses the Constant Difference of Elasticity (CDE) function from the standard GTAP model, but calibrates income elasticity in each calculation step based on a functional relationship between PPP-corrected GDP per capita and income elasticities. The base of this estimation is the relationship that is found in the GTAP database, but consistent with GTAP elasticities these functions are scaled down. This is required to get land use changes that are consistent with long term income elasticities, but the procedure is very ad hoc, and should be improved based on empirical estimates.

The calibration procedure is done before the model starts to run in the construction procedure of the database, and is updated each step of the EULER optimization routine used in simulating the model. This procedure is very general, and makes all the welfare calculations in the standard GTAP model applicable, while the income elasticities are dynamic.

The basic idea is that the income elasticity is determined by an externally determined income elasticity function where the income elasticity depends on real GDP per capita. The service sector is used as the residual to guarantee that the sum of the income elasticities equals 1. During the initialization procedure of the data, the CDE consumption function parameters have been initialized consistent with this function, but during the run the parameters are continuously updated in an iterative process.

In practical implementation, cross price elasticities are almost zero in the CDE function. And more fundamentally, because the difference in cross price elasticity with respect to the price of one sector to another sector is by definition the same, no groups of goods that are good substitutes can be separated. This is not very plausible. For example, it seems plausible that the cross price elasticity of consumption between cattle meat and other meat is relatively high. But for the moment the focus remains on the adjustment of the income elasticities over time, that is of fundamental importance in understanding the long term dynamics of a fast growing economy like the Indian economy.

In MAGNET the structure of income elasticities implicit in the GTAP database is used, but important reductions in the direction of elasticities used by FAO are applied for agricultural commodities. Furthermore, the elasticities have been made dynamic. These dynamic elasticities depend on the development of GDP per capita. In order to make income and price elasticities consistent with those in Deliverable 5.1 of TAPSIM, i.e. the study by Joshi and Kumar, the formula for income elasticities has been shifted in such a way that the income elasticities in 2007 are consistent with those used by Joshi and Kumar. The shifter is shown in the column "Adjustment" in table 7.1. For the price elasticities, the estimates in Joshi and Kumar are used directly, where the CDE consumption function in the model is constantly recalibrated in order to keep these price elasticities constant.

Table 7-1 Correction on income and price elasticities based on D5.1

Income Elasticity				Price elasticity		
EYP	MAGNET	Joshi/Kumar	Adjustment		MAGNET	Joshi/Kumar
rice	0.16	0.026	-0.134	1 rice	-0.14	-0.291
wht	0.16	0.083	-0.077	2 wht	-0.12	-0.379
grain	0.16	-0.148	-0.308	3 grain	-0.12	-0.248

oils	0.16	0.259	0.099	4 oils	-0.12	-0.492
sug	0.16	0.064	-0.096	5 sug	-0.12	-0.343
hort	0.5	0.3	-0.2	6 hort	-0.15	-0.55
cattle	0.67	0.651	-0.019	9 cattle	-0.21	-0.837
oap	0.67	0.651	-0.019	10 oap	-0.21	-0.837
milk	0.42	0.377	-0.043	11 milk	-0.26	-0.605
Sugar	0.65	0.064	-0.586	12 sugar	-0.15	-0.343
Vol	1.25	0.259	-0.991	13 vol	-0.16	-0.492
Ofd	0.82	0.520	-0.300	14 ofd	-0.17	
Fish	1.63	0.651	-0.979	15 fish	-0.21	-0.837
Bevtab	1.63	0.736	-0.894	16 bevtab	-0.16	-0.923

7.5 Conclusion

The results for a baseline depend very much on the assumptions on technological change and assumptions on income and price elasticities. For the TAPSIM baseline a relatively refined system of technology assumptions has been developed, while income and price elasticities that are standardly applied by the dynamic consumption function of MAGNET are adjusted to information in D5.1 of TAPSIM. International projections are based USDA population and GDP projections, while for India specific assumptions have been made that GDP growth will be 8% per year till 2030. Labour supply projections are based on the assumptions made in the national CGE model used in TAPSIM. Land productivity increases are a combination of FAO projections and developments of labour productivity in the baseline.

8 Conclusion

The adaptation of MAGNET to use for TAPSIM has been accomplished at the same time that the fundamental structure of the model from LEITAP2 into MAGNET has taken place. This required some extra effort. The advantage of the new MAGNET structure is its flexibility and the direct relationship between the data of the data source and the data as used in the model through programmed procedures. Also the flexibility to change the structure of the model for questions at hand is an important advantage. The cost was that sometimes that the implementation of the model for TAPSIM was done in two stages: first in the old LEITAP2 model, then in again in a different way in the MAGNET model.

During the development of the new elements for the MAGNET model for India a lot of new and flexible options have been included, like the modelling of dynamic international capital flows, procedures for the introduction of new sectors and commodities, procedures to include tariff data in the database, procedures to calculate shocks for the analysis of trade agreements, the introduction of a flexible Armington structure, and a general procedure to adjust the SAM of a country in the international database. These procedures make the model flexible to use in the future: the improvements made can be easily updated for new data and the structure can be adjusted when new questions arise.

For the international model a baseline has been designed that is based on GDP and population projections in combination with projections of labour supply. The introduction of the dynamic international capital market makes the growth of the capital stock endogenous and therefore doesn't require assumptions on capital supply growth. In deliverable 7.1 the results of the baseline will be discussed, while in deliverable 7.2 a number of scenarios will be analysed.

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