1.1 LEITAP (adapted version from GTAP)

The analysis is carried out with an adapted version of the general equilibrium model of the Global Trade Analysis Project (GTAP, Hertel, 1997). The first part of this section provides a brief overview of the standard GTAP model and the second part we focus on extensions. In section 1.3 we discuss the data and in section 1.4 we describe the projection assumptions.

1.1 Global Trade Analyses Project: The standard Model

GTAP was initiated with the goal of supporting high-level quantitative analysis of international trade, resource, and environmental issues in an economy wide context. The GTAP project is supported by the leading international agencies (e.g. WTO, Worldbank, OECD, UNCTAD) in trade and development policy, as well as a number of national agencies with active research programs on these issues. The GTAP project develops and maintains a database, a multi-region multi-sector general equilibrium model. It also provides training courses and organizes an annual conference on global economic analysis. This project has grown rapidly since its inception in 1993. There is no doubt that the GTAP database and its associated modelling efforts represent a major achievement for advancing quantitative analysis of international trade, resource and environmental issues. The success of this approach is reflected in a high degree of academic recognition as well as the increasing usage for policy analysis by international and national agencies.

1.1.1 Standard model characteristics

There are basically two strands of quantitative modelling in policy analysis. One approach is to build issue-specific models, depending on the question at hand. These models will usually be capable of capturing many relevant aspects of one specific policy question, but are of less use in a different policy context. The other approach sets out to construct more general and flexible models, which do not necessarily attempt to capture all detail but are flexible enough to allow elaborations in face of specific policy questions. The Global Trade Analysis Project (GTAP) provides such a modelling framework.

The standard GTAP model[1] is a comparative static multi-regional general equilibrium model. In its standard version constant returns to scale and perfect competition are assumed in all markets for outputs and inputs. A detailed discussion of the basic algebraic model structure of the GTAP model can be found in Hertel and Tsigas (1997)[2]. In the GTAP model each country or region is depicted within the same structural model.

[1] We deliberately refer to the 'standard GTAP model' as the model version that is supported by the GTAP consortium. GTAP users have developed numerous variations on the standard model. In this study we also make some modifications to the standard model. These are discussed more extensively in subsequent chapters

[2] Or in the internet http://www.agecon.purdue.edu/gtap/model/chap2.pdf

The general conceptual structure of a regional economy in the model is represented in Figure 5.2. Within each region, firms produce output, employing land, labour, capital, and natural resources and combining these with intermediate inputs. Firm output is purchased by consumers, government, the investment sector, and by other firms. Firm output can also be sold for export. Land is only employed in the agricultural sectors, while capital and labour (both skilled and unskilled) are mobile between all production sectors.

The model is characterized by an input-output structure (based on regional and national input-output tables) that explicitly links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembling of goods and services for consumption. Inter-sectoral linkages are direct, like the input of steel in the production of transport equipment, and indirect, via intermediate use in other sectors. The model captures these linkages by modelling firms' use of factors and intermediate inputs. The most important aspects of the model can be summarized as follows: (i) it covers all world trade and production; (ii) it includes intermediate linkages between sectors;

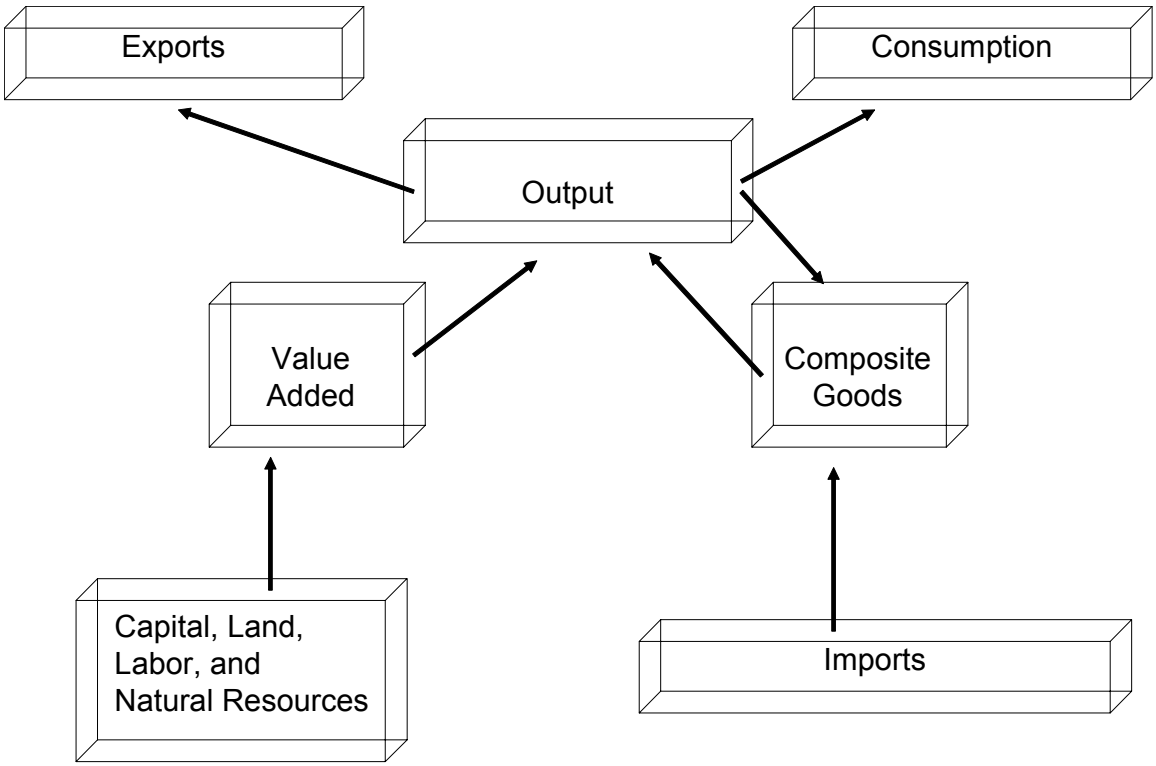

Figure 5.2: the flow of production

The consumer side is represented by the regional household to which the income of factors, tariff revenues and taxes are assigned. The regional household allocates its

income to three expenditure categories: private household expenditures, government expenditures and savings. For the consumption of the private household, the non-homothetic Constant Difference of Elasticities (CDE) function is applied.

In the model, a representative producer for each sector of a country or region makes production decisions to maximize a profit function by choosing inputs of labor, capital, and intermediates to produce a single sectoral output. In the case of crop production, farmers also make decisions on land allocation. Intermediate inputs are produced domestically or imported, while primary factors cannot move across countries. Markets are typically assumed to be competitive. When making production decision, farmers and firms treat prices for output and input as given. Primary production factors land and capital are fully employed within each economy, and hence returns to land and capital are endogenously determined at the equilibrium, i.e., the aggregate supply of each factor equals its demand.

The production structure is depicted with a production tree with four nests (Figure 1). The Leontief and the Constant Elasticity of Substitution (CES) functional forms are used to model the substitution relations between the inputs of the production process. In the output nest, the mix of factors and intermediate inputs are assembled together, forming the sectoral output. The functional form can be Leontief (fixed proportions) or CES. The substitution relations within the value added nest are depicted by the CES function. While labor and capital are considered mobile across sectors the Constant Elasticity of Transformation (CET) function is used to represent the sluggish adjustment of the factor land. That is, land can only imperfectly move between alternative crop uses. The CES function is applied in the composite intermediate nest depicting the substitution between domestic and imported products. The last nest illustrates the relation between imports of the same good from different regions. The Armington approach treats products from different regions as imperfect substitutes.

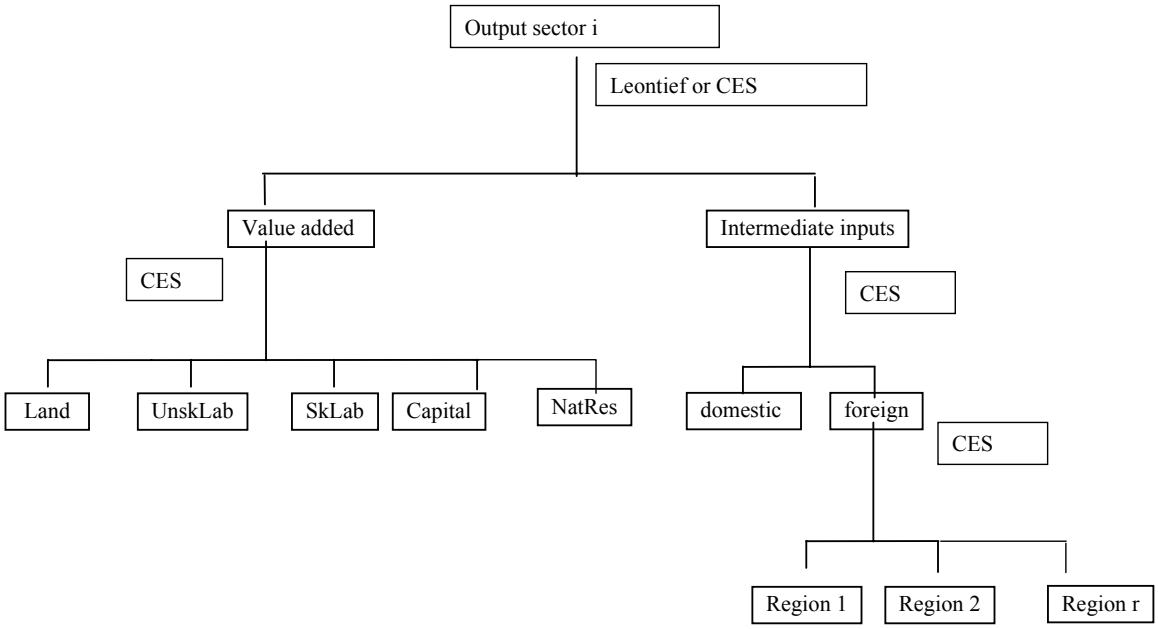

Figure 5.3: Production tree (Source: Hertel and Tsigas (1997)).

Prices on goods and factors adjust until all markets are simultaneously in (general) equilibrium. This means that we solve for equilibria in which all markets clear. While we model changes in gross trade flows, we do not model changes in net international capital flows. Rather our capital market closure involves fixed net capital inflows and outflows. (This does not preclude changes in gross capital flows). To summarize, factor markets are competitive, and labor and capital are mobile between sectors but not between regions.

The GTAP model includes two global institutions. All transport between regions is carried out by the international transport sector. The trading costs reflect the transaction costs involved in international trade, as well as the physical activity of transportation itself. Using transport inputs from all regions the international transport sector minimizes its costs under the Cobb-Douglas technology. The second global institution is the global bank, which takes the savings from all regions and purchases investment goods in all regions depending on the expected rates of return. The global bank guarantees that global savings are equal to global investments. With the standard closure, the model determines the trade balance in each region endogenously, and hence foreign capital inflows may supplement domestic savings. The model does not have an exchange rate variable. However, by choosing as a numeraire an index of global factor prices, each region's change of factor prices relative to the numeraire directly reflects a change in the purchasing power of the region's factor incomes on the world market. This is can be directly interpreted as a change in the real exchange rate.

The welfare changes are measured by the equivalent variation, which can be computed from each region's household expenditure function.

Taxes and other policy measures are included in the theory of the model at several levels. All policy instruments are represented as ad valorem tax equivalents. These create wedges between the undistorted prices and the policy-inclusive prices. Production taxes are placed on intermediate or primary inputs, or on output. Trade policy instruments include applied most-favored nation tariffs, antidumping duties, countervailing duties, price undertakings, export quotas, and other trade restrictions. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

The GTAP model is implemented in GEMPACK - a software package designed for solving large applied general equilibrium models. A description of Gempack can be found in Harrison and Pearson (2002)[3].

Various GTAP users have developed adaptations of the standard model. Such elaboration's, include increasing returns to scale and imperfect competition, dynamic equilibrium formulations and incorporation of non-continuous policy instruments such as Tariff rate quota that resulted from GATT Uruguay round, or production

[3] More information can be obtained at www.monash.edu.au.policy/gempack.htm

quota as applied in the European milk and sugar sectors. For a model version that uses both increasing returns and production quota, see Francois et al. (2002) and Francois et al. (2003).

1.1.2 Extensions to the standard GTAP model:

For the purpose of the EURURALIS study, we have constructed a special purpose version of the GTAP database and model, designed to make it more appropriate for the analyses of the agricultural sector. We use information from the OECDs Policy Evaluation Model (PEM) to improve the production structure.

1.1.2.1 Land allocation:

The base version of GTAP represents land allocation in a CET (Constant Elasticity of Transformation) structure (See left part of Figure 3). It is assumed that the various types of land are imperfectly substitutable, but the substitutability is equal amongh all land types. We extended the land allocation structure by taking into account that the degree of substitutability of types of land can be varied between types. We use the OECDs Policy Evaluation Model (PEM) structure although it has more detail. It distinguishes different types of land in a nested 3-level CET structure[4] . The model covers several types of land more or less suited to various crops (i.e. cereal grains, oilseeds, sugar cane/sugar beet and other agricultural uses). The lower nest assumes a constant elasticity of transformation between 'vegetable fruit and nuts', 'Other crops' (e.g. rice, plant based fibres), and the group 'Field crops and pastures' (FCP). The transformation is governed by the elasticity of transformation σ1. The FCP- group is itself a CET aggregate of Cattle and Raw Milk (both Pastureland), Sugarcane and beet, and the group of 'Cereal, Oilseed and Protein cropland' (COP). Here the elasticity of transformation is σ2. Finally, the transformation of land within the upper nest, the COP-group, is modelled with an elasticity σ3.
In this way the degree of substitutability of types of land can be varied between the nests. It captures to some extent agronomic features. In general it is assumed that $\sigma 3 > \sigma 2 > \sigma 1$. This means that it is more easy to change the allocation of land within the COP group, while it is more difficult to move land out of COP production into, say, vegetables.

[4] This is relatively recent feature of PEM. Earlier versions had a 2-level structure

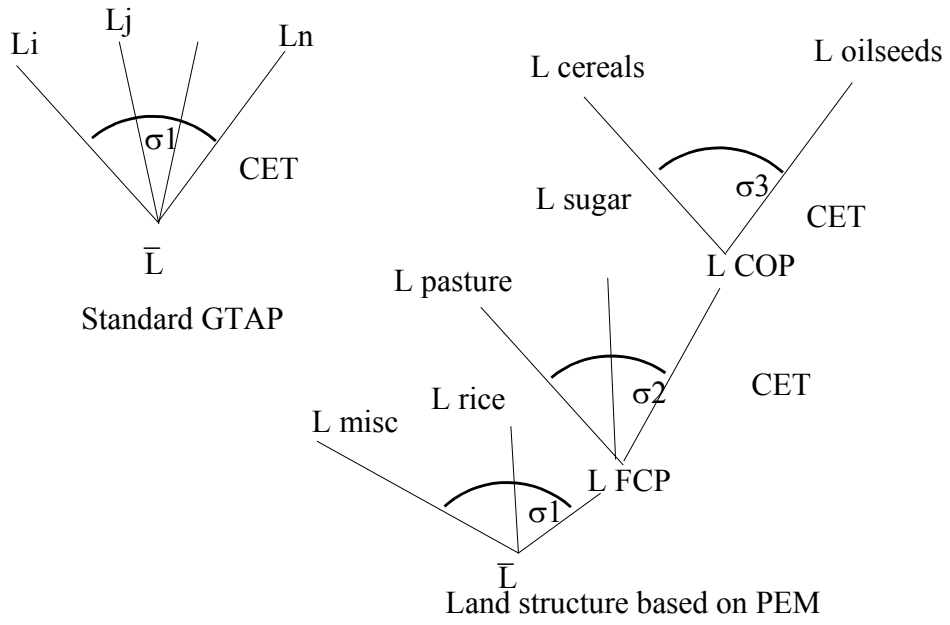

Figure 5.4: Land allocation 'tree'

1.1.2.2 Land supply

The land supply is modelled using a land supply curve which specifies the relation between land supply and rental rate proposed by Abler[5], 2003. Land supply to agriculture as whole can adjust because of idling of agricultural land, conversion of non-agricultural land to agriculture, conversion of agricultural land to urban uses and agricultural land abandonment.

When land conversion and abandonment possibilities are low then the elasticity of land supply in respect to land rental rates is small and land supply curve is steep in the reverse case the land supply curve is flat. This leads to the land supply curve presented in figure 5.5.

Following Abler, we have assumed low land supply elasticities for North America and EU and high elasticities for low developed countries.

We have assumed the following land supply function:

Land supply = a - b/real land price

where: a (>) is an asymptote, b is a positive parameter and the land supply elasticity is equal to: b/(a · real land price – b). To calibrate the function to the GTAP 2001 data concerning land supply per region. The asymptote was calculated using predicted by

[5] David Abler, 2003, Adjustment at the Sectoral Level, An IAPRAP workshop on Policy Reform and Adjustment, The Wye Campus of Imperial College, October 23-25, 2003

FAO land growth rates up to 2030. The value of the parameter b follows from land supply formula.

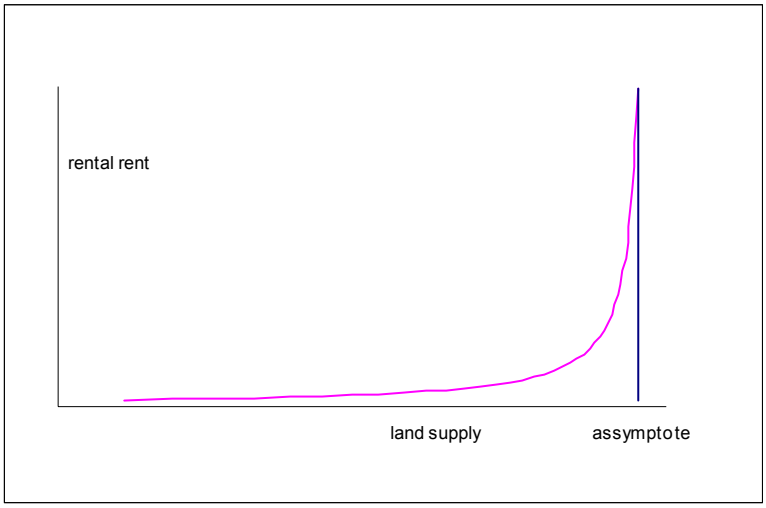

Figure 5.5: Land allocation curve

1.1.2.3 Factor markets for labour and capital/ Segmentation

If labour were perfectly mobile across domestic sectors, we would observe equalized wages throughout the economy for workers with comparable endowments. This is clearly not supported by evidence. Wage differentials between agriculture and non-agriculture can be sustained in many countries (especially developing countries) through limited off-farm labour migration. (de Janvry. 1991, Harris, Todaro 19..). Returns o assets invested in agriculture also tend to diverge from returns of investment in other activities.

To capture these stylized facts, we incorporate segmented factor markets for labour and capital by specifying a CET structure that transforms agricultural labour (and capital) into non-agricultural labour (and capital). This specification has the advantage that it can be calibrated to available estimates of agricultural labour supply response. In order to have separate market clearing conditions for agriculture and non-agriculture, we need to segment these factor markets, with a finite elasticity of transformation. We also have separate market prices for each of these sets of endowments.

The economy-wide endowment of labour (and capital) remains fixed, so that any increase in supply of labour to manufacturing has to be withdrawn from agriculture, and the economy-wide resources constraint remains satisfied. (Similarly for capital). The elasticities of trasformation can be calibrated to fit estimates of the elasticity of labour supply from OECD (2001).

1.1.2.4 Agricultural quotas

An output quota places a restriction on the volume of production. If such a supply restriction is binding, it implies that consumers will pay a higher price than they would pay in case of an unrestricted interplay of demand and supply. A wedge is created between the prices that consumers pay, PM and the marginal cost for the producer, PS. Figure 4 below illustrates this point. The vertical distance between PM and PS at quota levels is known as the tax equivalent of the quota rent.

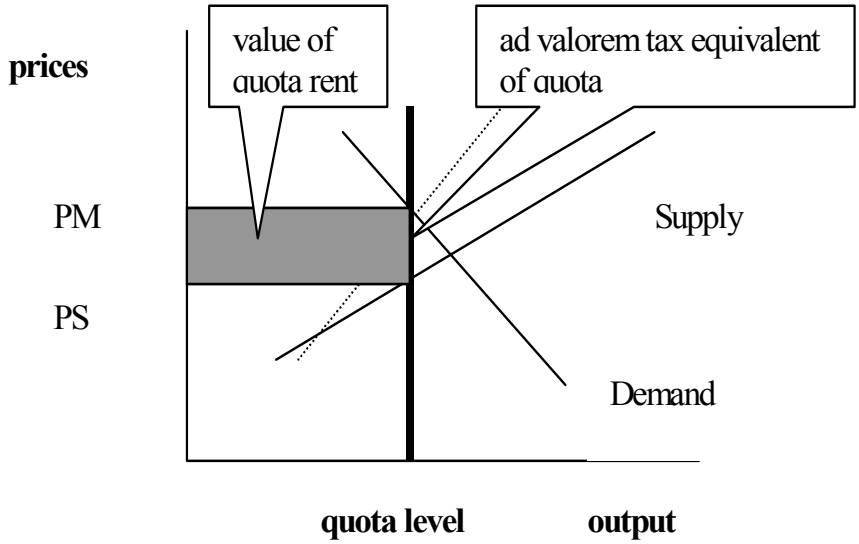

Figure 5.5: Production quota

In our model both the EU milk quota and the sugar quota are implemented at the national level. Technically, this is achieved by formulating the quota as a complementarity problem. This formulation allows for endogenous regime switches from a state when the output quota is binding to a state when the quota becomes non-binding. In addition, changes in the value of the quota rent are endogenously determined. If □ denotes the tax equivalent of the quota rent, and denotes the difference between the output quota and output , then the complementary problem can be written as:

$$\tau \geq 0 \perp Y$$

where either

	$\tau > 0$ and $Y = 0$	the quota is binding
or	$\tau = 0$ and $Y \geq 0$	the quota is not binding

1.1.3 Data

The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages. All monetary values of the data are in $US millions and the base year for version 6 is 2001. This version of the database divides the world into 88 regions. An additional interesting feature of version 6 is the distinction of the 25 individual EU member states. The database distinguishes 57 sectors in each of the regions. That is, for each of the 65 regions there are input-output tables with 57 sectors that depict the backward and forward linkages amongst activities. The database provides quite a great detail on agriculture, with 14 primary agricultural sectors and seven agricultural processing sectors (such as dairy, meat products and further processing sectors)

The bilateral trade data are derived from United Nations Trade Statistics, and support- and protection data from various sources (e.g. UNCTAD TRAINS database for industrial tariff information, the AMAD database for agricultural protection, OECD's PSE data base for domestic agricultural support). Version 5 is fully documented in Dimaranan and McDougall (2002). Version 6.2 will be availablew soon.

For Eururalis the social accounting data have been aggregated to 13 sectors and 37 regions (see Annex). The sectoral aggregation distinguishes agricultural sectors that use land and sectors engaged in the Common agricultural policy (CAP). The regional aggregation .

1.1.4 Projections

The size GDP growth is exogenous. It is taken from CPB-scenarios presented in "Four futures for Europe" (Lejour. 2003). We also take employment and capital growth from the CPB scenario's. Since we targeting GDP growth the total factor productivity (TFP) growth is determined by the model. When targeting TFP, we assume different rates and mechanisms for sectoral factor productivity development.

References:

Standard GTAP and DATA:
- Dimaranan, B.V. and McDougall R.A., 2002. Global Trade, Assistance, and Production: The GTAP 5 Data Base. Center for Global Trade Analysis, Purdue University, U.S.
- Hertel (ed.), 1997, *Global Trade Analysis. Modelling and Applications*. Cambridge University Press.

Extensions of the standard model used in this study:
- Eickhout, Bas, Hans van Meijl, Andrzej Tabeau, and Henk van Zeijts (2004), Between Liberalization and Protection: Four Long-term Scenarios for Trade, Poverty and the Environment, Presented at the Seventh Annual Conference on Global Economic Analysis, june, Washington, USA.
- Francois, J., Van Meijl, H. and Van Tongeren, F. 2003.'Trade Liberalization and Developing Countries Under the Doha Round. CEPR Discussion Paper no. 4032. London, Centre for Economic Policy Research
- Huang, Hsin, Frank van Tongeren, Joe Dewbre and Hans van Meijl (2004), A New Representation of Agricultural Production Technology in GTAP
Paper presented at the Seventh Annual Conference on Global Economic Analysis, june, Washington, USA..
- Meijl, H. van and F.W. van Tongeren, (2002), The Agenda 2000 CAP reform, world prices and GATT-WTO export constraints, *European Review of Agricultural Economics*, Vol 29 (4) (2002) pp. 445-470.
- Tongeren, F.W., H. van Meijl and Y. Surry, (2001), Global models of trade in agriculture and related environmental modelling: a review and assessment, *Agricultural economics*, Vol 26/2, p.149-172.

For GTAP applications and papers published in scientif journals, see WWW.GTAP.ORG

- Appendix: Eururalis regions and comprising GTAP regions

EURALIS regions		Comprising GTAP regions	
No. Code	Description	No. Code	Description
1belu	Belgium and Luxembourg	38bel	Belgium
		47lux	Luxembourg
2dnk	Denmark	39dnk	Denmark
3deu	Germany	42deu	Germany
4grc	Greece	44grc	Greece
5esp	Spain	50esp	Spain
6fra	France	41fra	France
7irl	Ireland	45irl	Ireland
8ita	Italy	46ita	Italy
9nld	The Netherlands	48nld	Netherlands
10aut	Austria	37aut	Austria
11prt	Portugal	49prt	Portugal
12fin	Finland	40fin	Finland
13swe	Sweden	51swe	Sweden
14gbr	United Kingdom	43gbr	United Kingdom
15euis	Cyprus, Malta	58cyp	Cyprus
		61mlt	Malta
16cze	Czech Republic	59cze	Czech Republic
17euba	EU Baltic countries	66est	Estonia
		67lva	Latvia
		68ltu	Lithuania
18hun	Hungary	60hun	Hungary
19pol	Poland	62pol	Poland
20svn	Slovenia	65svn	Slovenia
21svk	Slovakia	64svk	Slovakia
22apeu	EU applicants countries	56bgr	Bulgaria
		63rom	Romania

23reur	Resf of Europe	52che	Switzerland
		53xef	Rest of EFTA
		54xer	Rest of Europe
		55alb	Albania
		57hrv	Croatia
24fsu	Former SovieT Union	69rus	Russian Federation
		70xsu	Rest of Former Soviet Union
25tur	Turkey	71tur	Turkey
26usa	USA	22usa	United States
27can	Canada	21can	Canada
28cam	Central America	23mex	Mexico
		24xna	Rest of North America
		34xca	Central America
		35xfa	Rest of FTAA
		36xcb	Rest of the Caribbean
29sam	South America	25col	Colombia
		26per	Peru
		27ven	Venezuela
		28xap	Rest of Andean Pact
		29arg	Argentina
		30bra	Brazil
		31chl	Chile
		32ury	Uruguay
		33xsm	Rest of South America
30oce	Australia, New Zealand	1aus	Australia
		2nzl	New Zealand
		3xoc	Rest of Oceania
31jap	Japan	6jpn	Japan
32eas	East Asia	4chn	China
		5hkg	Hong Kong
		7kor	Korea
		8twn	Taiwan
		9xea	Rest of East Asia
33seas	South-East Asia	10idn	Indonesia
		11mys	Malaysia
		12phl	Philippines
		13sgp	Singapore
		14tha	Thailand
		15vnm	Vietnam
		16xse	Rest of Southeast Asia
		17bgd	Bangladesh
		18ind	India
		19lka	Sri Lanka

		20xsa	Rest of South Asia
34meast	Rest of Middle East	72xme	Rest of Middle East
35naf	North Africa	73mar	Morocco
		74xnf	Rest of North Africa
36caf	Central Africa	83xsd	Rest of SADC
		84uga	Uganda
		85xss	Rest of Sub-Saharan Africa
37saf	South Africa	75bwa	Botswana
		76zaf	South Africa
		77xsc	Rest of South African CU
		78mwi	Malawi
		79moz	Mozambique
		80tza	Tanzania
		81zmb	Zambia
		82zwe	Zimbabwe

EURALIS sectors		Comprising GTAP sectors	
No. Code	Description	No. Code	Description
1grain	Cereal grains nec	2wht	Wheat
		3gro	Cereal grains nec
2oils	Oil seeds	5osd	Oil seeds
3sug	Sugar cane and beet, sugar	6c_b	Sugar cane, sugar beet
4hort	Vegetables, fruit, nuts	4v_f	Vegetables, fruit, nuts
5crops	Other crops	1pdr	Paddy rice
		7pfb	Plant-based fibers
		8ocr	Crops nec
6cattle	Cattle,sheep,goats,horses	9ctl	Cattle,sheep,goats,horses
		19cmt	Meat: cattle,sheep,goats,horse
7oap	Animal products nec	10oap	Animal products nec
		20omt	Meat products nec
8milk	Raw milk	11rmk	Raw milk
9dairy	Dairy products	22mil	Dairy products
10sugar	Sugar	24sgr	Sugar
11agro	Other agr-food products	12wol	Wool, silk-worm cocoons
		13frs	Forestry
		14fsh	Fishing
		21vol	Vegetable oils and fats
		23pcr	Processed rice
		25ofd	Food products nec
		26b_t	Beverages and tobacco products
12ind	Industry	15coa	Coal
		16oil	Oil
		17gas	Gas
		18omn	Minerals nec
		27tex	Textiles
		28wap	Wearing apparel
		29lea	Leather products
		30lum	Wood products
		31ppp	Paper products, publishing
		32p_c	Petroleum, coal products
		33crp	Chemical,rubber,plastic prods
		34nmm	Mineral products nec
		35i_s	Ferrous metals
		36nfm	Metals nec
		37fmp	Metal products
		38mvh	Motor vehicles and parts

		39otn	Transport equipment nec
		40ele	Electronic equipment
		41ome	Machinery and equipment nec
		42omf	Manufactures nec
13ser	Services	43ely	Electricity
		44gdt	Gas manufacture, distribution
		45wtr	Water
		46cns	Construction
		47trd	Trade
		48otp	Transport nec
		49wtp	Sea transport
		50atp	Air transport
		51cmn	Communication
		52ofi	Financial services nec
		53isr	Insurance
		54obs	Business services nec
		55ros	Recreation and other services
		56osg	PubAdmin/Defence/Health/Educat
		57dwe	Dwellings