SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

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DYNAMIC REGIONAL AND GLOBAL MULTI-SECTORAL MODELLING FOR BELGIUM ECONOMY (GREENMOD)

CP-14

ULB

SPSD II

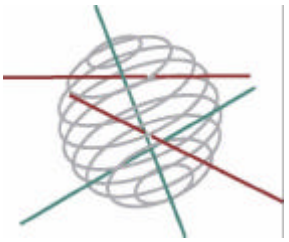
PART 1

SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS

- GENERAL ISSUES
- AGRO-FOOD
- ENERGY
- TRANSPORT

This research project is realised within the framework of the Scientific support plan for a sustainable developmentpolicy (SPSD II)

Part I "Sustainable production and consumption patterns"



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Belgian Public Planning Service Science Policy
Rue de la Science 8 - Wetenschapsstraat
B-1000 Brussels
Belgium
Tel : 32/2/238.34.11 – Fax 32/2/230.59.12
http://www.belspo.be (FEDRA)

Contact person :
Mrs Aurore Delis (deli@belspo.be)
Tel : 02/238.37.61

GREENMOD

DYNAMIC REGIONAL AND GLOBAL MULTI-SECTORAL MODELLING FOR BELGIUM

INTERMEDIARY REPORT AND ANNEXES

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1. INTRODUCTION

1.1. Context and summary

Since the ratification of the Kyoto Protocol by the European Union in May 2002 and the "Burden Sharing Agreement" between the EU Member States, several environmental policy measures have been considered and widely debated in Belgium and in other countries. Under the "Burden Sharing Agreement", Belgium committed herself to reduce her greenhouse gas emissions by 7.5 percent by 2008-2012 compared to 1990 levels. Therefore, it is important to examine the economic and environmental impacts of implementing the Kyoto Protocol on the three Belgian regions (Brussels, Flanders and Wallonia).

Until now, very few studies have examined the impact of environmental policies at both sectoral and regional levels in Belgium. The lack of detailed studies at the regional level is due to the absence of quantitative tools capable of taking into account both sectoral and regional dimensions of environmental policies in a consistent framework.

In spite of the importance of the challenges the three regions of Belgium have to face, in spite of the permanent debate on the policies to follow, on the reforms to implement, there is no regional model in Belgium to help policy makers. The continuous evolution of the Belgian State toward a federal structure and the perspective of even further transfer of powers to the regional governments plead in favour of a modern and powerful quantitative tool to help policy makers take better decisions. This project aims at filling this important gap by building a multi-regional and multi-sectoral dynamic general equilibrium model imbedded in an international model. The model is destined to become a lasting, flexible tool to contribute to the energy and environmental policy assessment.

Beyond building this model as an instrument for helping in the decision-making process, the project will also explore the main challenges related to energy and climate policies in the socio-economic, energetic and environmental fields, and especially in the analysis of the impacts of policies and measures related to climate change. A special attention will be given to the tradable emission permits and their interaction with other instruments (fiscal, non-fiscal, voluntary agreements, etc.).

The first year of the project was devoted to data collection, the development of a detailed sectoral and regional database for Belgium, the construction of a simplified version of the model GreenMod and its implementation in the software GAMS, and finally to the review of the literature regarding tradable pollution permits. All these tasks have been successfully carried out. During the second year of the project, the Belgian multi-regional and multi-sectoral database will be integrated within an aggregated version of the international database GTAP (version 5) and the current version of the model will be further disaggregated and extended to include other countries/regions of the world. This version will cover the permit markets at the Belgian, European and international markets. Once the recursively dynamic version is fully tested and finalised, we will use it for policy analysis.

1.2. Objectives

The main objective of this project is to develop a dynamic, multi-regional, and multi-sectoral general equilibrium model of the Belgian economy integrated in a global model to analyse problems related to environment and energy. The regional/global model will hereafter be referred to as GreenMod.

GreenMod is intended to act as an analytical and quantitative support for decision-making in the energy and environment field, in particular for the policies to reduce greenhouse gas emissions. GreenMod also aims at filling the gaps left by the other models currently used in Belgium, in particular by explicit bottom-up modelling of the three Belgian regions (Brussels, Flanders, Wallonia) within the European and global setting, by further disaggregating the production and consumption blocs (twenty-six sectors/commodities), by distinguishing different types of households to study the distributional effects of environmental policies, and finally by introducing tradable permits along with other fiscal and non-fiscal economic policy instruments. The Belgian regional model will be fully integrated within an international model (European and global) of similar structure that will allow researchers to study the effects of co-ordinated and non-coordinated policies at the European and international level.

The project will also explore the main challenges related to energy and climate policies in the socio-economic, energetic and environmental fields and especially the analysis of the impacts of policies and measures relating to the climate field.

1.3. Expected outcomes

- A built-in multi-regional and multi-sectoral database integrated into multi-national data containing the input-output matrices, the inter-regional flows of goods and services, the capital and labour, the international flows of trade and bilateral investments, the detailed fiscal system, the energy consumption by sectors, and detailed data on the household sector in each one of the three Belgian regions.

- A dynamic, regional and multi-sectoral general equilibrium model (GreenMod) of the Belgian economy integrated in a global model for addressing energy and environmental issues. GreenMod is destined to become a lasting, flexible tool to contribute to the energy and environmental policy assessment and to act as a support for decision-making in energy and environmental matters, especially in the policies of pollution abatement. It will take into consideration all interdependencies at the level of the three regions (Brussels, Flanders and Wallonia), as well as at the European and global level in order to study the impacts related to economic measures in the energy and environment field. The model will also permit us to examine the differentiated impacts of economic measures on different socio-economic household groups.

- Baseline projections and analysis of various scenarios of implementation of the measures agreed upon in the Kyoto Protocol.

- Final report, manual and users' guide for the model.

- A book that presents the GreenMod model and its applications.

- Publication of several articles in international and Belgian scientific journals, several working papers, presentation of papers in scientific conferences in Belgium and abroad.

2. DETAILED DESCRIPTION OF THE SCIENTIFIC METHODOLOGY

The construction of the model GreenMod is based on the general equilibrium theory. General equilibrium modelling helps us to better evaluate the socio-economic and environmental impacts of different economic policy instruments. This assessment is achieved within a consistent setting (linked social accounting matrices, budget constraints, macro identities, etc.) and a rigorous theoretical framework.

General equilibrium models are based on individual (decentralised) optimising behaviour of economic agents. Because they take into account the distortions due to the tax and transfer system in force, they function under an optimum of second best. This is particularly important to keep in mind for correctly evaluating the impacts of fiscal policies under equal yield equilibrium or double dividend scenarios.

General equilibrium modelling allows the evaluation of the socio-economic, energetic and environmental impacts of the different economic instruments, should they be fiscal (direct and indirect fiscal policies, subsidies, etc.) or non-fiscal (support for replacement technologies, etc.). This evaluation is realised under a coherent framework in terms of macro identities (national accounts and agent accounts), of distribution of the revenues in the economy (social accounting matrix) and under strict consistency with the economic theory.

A large level of detail is indispensable in order to show and evaluate the structural adjustments generated by the pollution abatement policies. We know that the main challenges of these policies are at the sectoral level. The sectoral (26 sectors/commodities for every region and country of the model) and the regional (Brussels, Flanders and Wallonia) disaggregation are therefore essential. The regional dimension is very of great importance given that each region in Belgium has its own structural features and needs specific abatement strategies.

GreenMod compares the effects of alternative economic policies in terms of a large number of sectoral and national variables such as sectoral output, employment, investment, and welfare. It evaluates the impacts of the greenhouse gases (CO2, CH4 and N2O). It describes the challenge in terms of budget for every agent, including the federal and regional public administrations.

The project includes the following stages and features:

2.1. Construction of the database

The construction of the GreenMod model requires a very disaggregated database. The first year of the project was mainly dedicated to gathering the raw data, analysing, harmonising and updating it, as well as to constructing the regional social accounting matrices and their integration in the international database extracted from the version 5 of the GTAP database.

2.2. Construction of the model

GreenMod takes into account all the interdependences between the three regions (Brussels, Flanders and Wallonia) in order to study the impacts of economic measures related to energy and environment. At a later stage, the model will also provide the distributional effects of environmental measures thanks to the disaggregation of the household block into several socio-economic groups.

The final version of the model will include the following features[1]:

- regional aspects: the model includes all three regions of Belgium (Brussels, Flanders and Wallonia) and their interactions;
- sectoral aspects: the model includes all the important sectors of the three regions (26 sectors are distinguished);
- dynamics: the model provides the short, medium and long-term effects of economic policies and external shocks. The temporal horizon of the model is flexible and the model can be dynamically solved with annual steps over any number of years;
- tax system and institutions: the model includes all the important elements of the federal, regional and local tax systems, as well as the institutional particularities in which the three Regions operate;
- disaggregation of the households: energy and environmental policies imply different distributive effects (Bayar, 1993) among different socio-economic groups or income classes. It is therefore important for the policymakers to have knowledge of the distributive effects of their decisions. GreenMod will be able to provide such information since the household block will be disaggregated (at least in deciles) in each one of the regions.
- labour market: particular attention is devoted to the modelling of the labour market in order to realistically take into account its particularities. The model takes into account the disequilibrium on the labour market. The mobility of the factors, in particular the commuters, is explicitly modelled. GreenMod allows us to analyse the effects of the environmental policies on employment and unemployment. The final version of the model will distinguish several categories of households and skills;
- international setting: the final version of the model will include the economic links of Belgium with the other countries of the European Union and with the other major economies of the world (United States, Japan, Russia and other transition economies, candidate countries to the EU, other countries of the OECD, China, India, Brazil, Southeast Asia, oil exporting countries, rest of the world);
- new technologies: the model will include backstop technologies.

2.3. Analysis and modelling of the tradable pollution permits.

The research team of the project has already carried out an analytical and critical survey on tradable permits and their introduction in environmental models. This will allow us to develop in 2003 a relevant modelling of tradable permits in order to take into account the regional (in Belgium), European and international dimensions of the permit markets. The tradable permit market will be introduced in GreenMod in a flexible way so that for simulation purposes we can easily include or exclude some sectors or geographic zones from the model.

The dynamic feature of the model will allow us to evaluate different modes of operating of the markets: methods of distribution and life span of the permits,

[1] The current version of the model includes already most of the features mentioned here.

monitoring and penalties, quotas gradually more restraining, etc. Particular attention will be paid to the implications on the technological choices.

Finally, a set of sensitivity tests will be carried out to compare the results provided by the model with those of other models and to put into light the main findings for the decision makers.

2.4. Policy analysis

As soon as the model is fully operational, it will be intensively used for a large number of simulations and analyses. We will first define a reference path (baseline) for the economy over a long time horizon by taking into account all the available data, projections, and studies in this field. A set of systematic exercises will then be carried out with regard to the links between the permits and the other measures (fiscal and non fiscal): taxes on the fossil energy sources, indirect and direct tax system, hybrid system, measures adopted for the agents excluded from the permit market (other productive sectors and households). The policy simulations will be determined in close cooperation with the Users' Committee of our project and with the OSTC.

3. DETAILED DESCRIPTION OF THE INTERMEDIARY RESULTS

The first year of the project was devoted to data collection, the development of a detailed sectoral and regional database for Belgium, the construction of a simplified version of the model GreenMod and its implementation in the software GAMS, and finally to the review of the literature regarding tradable pollution permits. All these tasks have been successfully carried out. In this section, we provide an overview of the results of this work. During the second year of the project, the Belgian multi-regional and multi-sectoral database will be integrated within an aggregated version of the international database GTAP (version 5).

3.1. Construction of the model database

GreenMod is designed to measure the direct, indirect and induced economic and environmental impacts of policy changes on an economy in the short, medium and long run. The input-output core enables the model to trace the extent and the channels of changes in policy and international environment. One of the major tasks for the first year of the project was to construct the core multi-regional and multi-sectoral database for Belgium. This task was extremely challenging, as there is no official regional input-output table or social accounting matrix in Belgium, and regional data is still scarce in many respects.

Regarding the data on energy, we contacted all the regional institutions working in the field of energy and environment to have access to their data. The complete list of energy types by sector is provided in annex 5.2. of this report.

The Flemish Institute for Technological Research (Vlaamse Instelling voor Technologisch Onderzoek - VITO) supplied the figures for Flanders. The Brussels Institute for the Environment Management (Institut Bruxellois pour la Gestion de l'Environnement - IBGE) provided the figures for Brussels and the figures for Wallonia were given by the General Directorate for Technology, Research and Energy (Direction Générale des Technologies, de la Recherche et de l'Energie - DGTRE) with the help of the Walloon Institute (Institut Wallon). The raw data collected at the

regional and national level were then analysed, harmonised and linked to the regional social accounting matrix.

The construction of a multi-regional (Flanders, Wallonia, Brussels) and a multi-sectoral database for GreenMod is explained in detail in annex 5.4.. Given the limited space allowed for this report (20 pages) and the highly technical and detailed nature of the process of building the database, we provide below only the main steps[2]:

Step 1: Collecting highly detailed raw data at the national and regional level on national accounts, regional accounts, input-output table, sectoral data (production, value added, employment, etc), public finance, household surveys, labour force surveys, data on energy use and pollution, trade data, global trade and energy database (GTAP version 5), etc.

Step 2: Analysis of raw data.

Step 3: Converting the latest national input-output table which is available for Belgium (for the year 1990) to the SEC95 principles (disaggregation of the input-output matrix into the 60 branches of activities (sectors) of the NACE-Revision 1 classification).

Step 4: Updating the 1990 national input-output matrix to the reference year 1997 (1997 is the latest year for which the global database GTAP is currently available).

Step 5: Building the social accounting matrix (SAM) for Belgium as a whole.

Step 6: Aggregating the national social accounting matrix to 26 sectors (this is currently the maximum disaggregation level given the limited data available at the regional level).

Step 7: Regionalisation of the Belgian social accounting matrix into three linked matrices for Flanders, Brussels, and Wallonia. Integration of all the national-regional public finance data in the regional SAM.

3.2. Construction of the model

3.2.1. General outline of the model

GreenMod is a dynamic multi-sector inter-regional computable general equilibrium (CGE) model for the Belgian economy, used to analyze problems related to environment and energy at the federal and regional levels. The core of the model is built in the tradition of Dervis, De Melo and Robinson (1982)[3], but accounts for region-specific elements and energy-environmental aspects.

The three regions of Belgium (Wallonia, Flanders and Brussels) are explicitly modelled in GreenMod, taking into account both the interdependences between each other and the links between each region and the rest of the world. The model incorporates the economic behaviour of four economic agents in each region: firms, households, government and the rest of the world. In addition to the agents described at the regional level, the federal government and the French Community are explicitly modelled.

All economic agents are assumed to adopt an optimizing behaviour under relevant budget constraints and all the markets operate under the perfect competition assumption. The goods-producing sectors, consisting of both public and private

[2] Details are provided in annex 5.4.

[3] Dervis, K., J. de Melo and S. Robinson [1982], *General equilibrium models for development policy,* Cambridge University Press, USA

enterprises, are disaggregated into 26 sectors[4]. Government behaviour is modelled at three different levels: federal, regional, and community. Both federal and regional tax systems are modelled in a detailed way. With regard to the rest of the world the economy is treated as a small open economy with no influence on (given) world market prices[5]. The model has a recursive dynamic structure composed of a sequence of several temporary equilibria, in which current savings determine future capital accumulation and the growth rate of the economy. The simulation horizon of the model is set at 25 years but can be extended in a flexible way. The model is solved dynamically with annual steps.

GreenMod is calibrated on the Belgian regional Social Accounting Matrix (SAM) for 1997 built by our team.

The following conventions are adopted for the presentation of the model. Variable names are given in capital letters, small letters denote parameters calibrated from the database (SAM) and Greek symbols are used for elasticity parameters. Subscript *i* stands for an identifier of one of the 26 production activities and also for an identifier of one of the 26 commodities. Subscript *r* stands for an identifier of one of three regions (Wallonia, Flanders and Brussels). Subscripts *ii* and *rr* stand for the transpose of *i* and *r*. Subscript *e* stands for an identifier of one of the five energy inputs and *ne* stands for non-energy inputs.

3.2.2. Firms

The CGE model does not take into account the behaviour of individual firms, but of groups of similar ones aggregated into sectors. The model distinguishes 26 production sectors (summarized in Appendix 5.5) for each region, which are modelled in the same way. Five of them – mining of coal and lignite, extraction of crude petroleum, extraction of natural gas, manufacturing of coke, refined petroleum and nuclear fuel and electricity, gas, steam and hot water supply – concern the supply and distribution of conventional energy. The remaining sectors concern the production of other goods and services.

The usual assumption for such a model is that producers operate on perfectly competitive markets and maximize profits (or minimize costs) to determine optimal levels of inputs and output. For example, for the firms operating internationally, the world market dictates the output price to a large extent, so, for an optimal outcome they have to produce as efficiently as possible. Some other firms are constrained in the costs level by domestic competitors. Thus, the optimizing producers minimize their production costs at every output level, given their production technology. Furthermore, production prices equal average and marginal costs, a condition that implies profit maximization for a constant returns to scale technology.

Gross output for each sector is determined from a nested production structure. At the outer nest producers are assumed to choose intermediate inputs of non-energy goods and a capital-labour-energy (KLE) bundle, according to a Leontief production function. At the second stage, producers choose the optimal level of labour input (L) and capital-energy composite (KE). Production substitution possibilities are reflected in this case by a constant elasticity of substitution (CES) function. The optimal level of capital (K) and energy (EN) is determined at the third stage, according to a CES function. Further, at the fourth stage, producers allocate the energy bundle between coal, crude oil, natural gas, refined oil and nuclear fuel, and electricity. Production substitution possibilities are again reflected by a CES function. The complex nested structure and the functional forms used in the production sectors are summarized in figure 3.2.1.

[4] A presentation of the production sectors considered in the model is given in Appendix 5.5.
[5] The final version of the model will be imbedded in a multi-sector and multi-national model. In this final version world prices will be endogenous.

Capital-labour-energy (KLE) bundle is related to output $\mathbf{XD_{i,r}}$ through a Leontief production function, which assumes an optimal allocation of inputs:

$$\mathbf{XD_{i,r}} = (\mathbf{1}/\mathbf{a_{i,r}}) \cdot \mathbf{KLE_{i,r}} = (\mathbf{1} - \mathbf{1}/\mathbf{a_{i,r}}) \cdot \mathbf{IO_{i,r}} \quad (3.2.1)$$

where $\mathbf{IO_{i,r}}$ denotes the intermediate inputs of non-energy goods of sector *i* in region *r*, and $\mathbf{1}/\mathbf{a_{i,r}}$ is the well-known fixed coefficient relating KLE composite to output. Further, KLE is a CES aggregation of capital-energy composite (KE) and labour (L):

$$\mathbf{KLE_{i,r}} = \mathbf{A_{i,r}^{KLE}} \cdot (\gamma \mathbf{F_{i,r}} \cdot \mathbf{KE_{i,r}^{-\rho F_{i,r}}} + (\mathbf{1} - \gamma \mathbf{F_{i,r}}) \cdot \mathbf{L_{i,r}^{-\rho F_{i,r}}})^{-\mathbf{1}/\rho \mathbf{F_{i,r}}} \quad (3.2.2)$$

Minimizing the costs function:

$$\mathbf{Cost_{i,r}}(\mathbf{KE_{i,r}}, \mathbf{L_{i,r}}) = \mathbf{PKE_r} \cdot \mathbf{KE_{i,r}} + \mathbf{PL_r} \cdot (\mathbf{1} + \mathbf{tl_{i,r}}) \cdot \mathbf{L_{i,r}} \quad (3.2.3)$$

subject to (3.2.2) yields the demand equations for capital-energy composite and labour (see appendix 5.6, equations 5.6.8 and 5.6.9), where $\mathbf{PL_r}$ is the regional average wage rate, $\mathbf{PKE_r}$ is the regional average price of the KE bundle, $\mathbf{tl_{i,r}}$ is the tax rate on labour use for sector *i* of region *r*, $\gamma \mathbf{F_{i,r}}$ is the share parameter and $\mathbf{A_{i,r}^{KLE}}$ is a shift parameter. The elasticity of substitution between capital-energy composite and labour is given by $\sigma \mathbf{F_{i,r}}$, where $\sigma \mathbf{F_{i,r}} = \mathbf{1}/(\mathbf{1} + \rho \mathbf{F_{i,r}})$. Both $\mathbf{PL_r}$ and $\mathbf{PKE_r}$ are assumed to be equal to one which implies that $\mathbf{KE_{i,r}}$ and $\mathbf{L_{i,r}}$ express the demand for capital-energy costs and labour costs per sector and region. The assumption regarding $\mathbf{PL_r}$ and $\mathbf{PKE_r}$ implies that both capital-energy and labour are perfectly mobile between sectors.

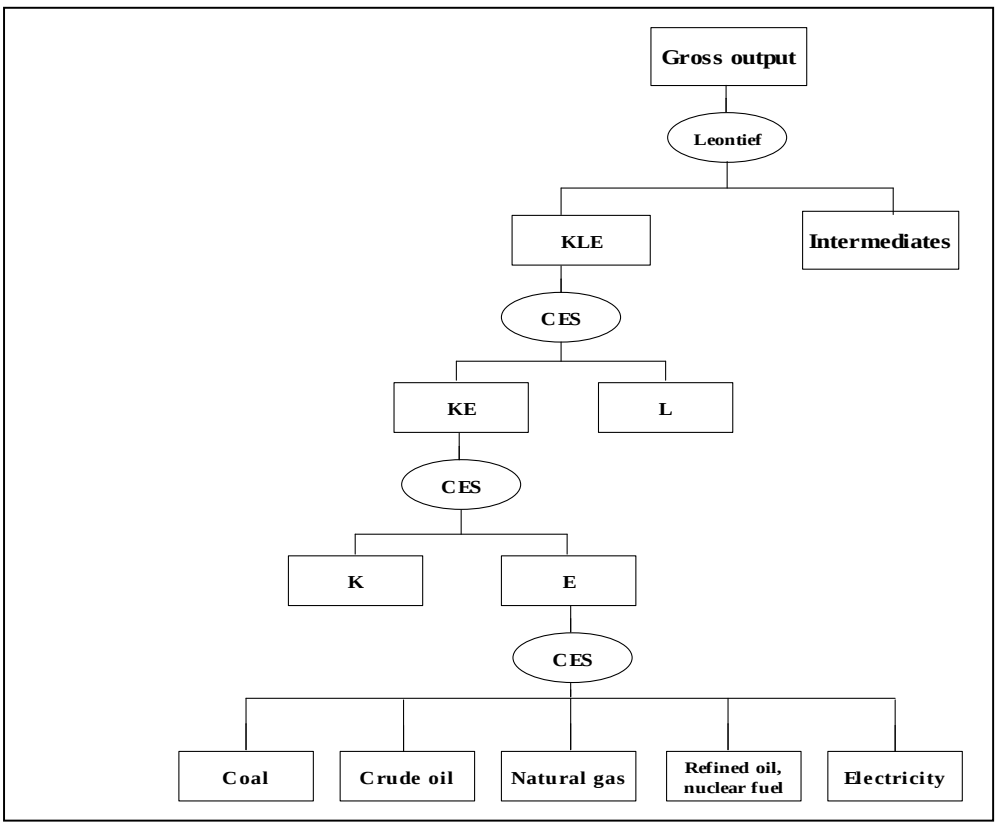

Figure 3.2.1. A nested CES and Leontief production technology

In the following stage, the producer determines the optimal choice of capital and energy demand, where capital-energy (KE) bundle is a CES composite of capital $(\mathbf{K}_{i,r})$ and energy $(\mathbf{EN}_{i,r})$:

$$\mathbf{KE}_{i,r} = \mathbf{A}_{i,r}^{\mathbf{KE}} \cdot (\gamma\mathbf{KE}_{i,r} \cdot \mathbf{K}_{i,r}^{-\rho\mathbf{KE}_{i,r}} + (\mathbf{1} - \gamma\mathbf{KE}_{i,r}) \cdot \mathbf{EN}_{i,r}^{-\rho\mathbf{KE}_{i,r}})^{-\mathbf{1}/\rho\mathbf{KE}_{i,r}} \quad (3.2.4)$$

Minimizing the costs:

$$\mathbf{Cost}_{i,r}(\mathbf{K}_{i,r}, \mathbf{EN}_{i,r}) = (\mathbf{1} + \mathbf{tk}_{i,r} + \mathbf{tkf}_{i,r}) \cdot \mathbf{PK}_{r} \cdot \mathbf{K}_{i,r} \cdot \mathbf{rdiff}_{i,r} + \mathbf{PEN}_{r} \cdot \mathbf{EN}_{i,r} \quad (3.2.5)$$

subject to (3.2.4) yields the demand equations for capital stock and energy (see appendix 5.6, equation 5.6.10 and 5.6.11), where $\mathbf{PK}_{r}$ is the regional-wide average capital rental rate, $\mathbf{rdiff}_{i,r}$ is the regional inter-sectoral differential rental rate, $\mathbf{PEN}_{r}$ is the regional-wide average price of energy bundle, $\mathbf{tk}_{i,r}$ is the regional tax rate on capital use for sector *i* of region *r*, $\mathbf{tkf}_{i,r}$ is the federal tax rate on capital use for sector *i* of region *r*, $\mathbf{A}_{i,r}^{\mathbf{KE}}$ is a shift parameter, $\gamma\mathbf{KE}_{i,r}$ is the share parameter and $\sigma\mathbf{KE}_{i,r}$ is the elasticity of substitution between capital and energy, where $\sigma\mathbf{KE}_{i,r} = \mathbf{1}/(\mathbf{1} + \rho\mathbf{KE}_{i,r})$.

Furthermore, the energy demand bundle is a CES aggregation of different energy inputs $(\mathbf{EI}_{e,i,r})$:

$$\mathbf{EN}_{i,r} = \mathbf{A}_{i,r}^{\mathbf{E}} \cdot (\sum_{e=1}^{5} \gamma\mathbf{E}_{e,i,r} \cdot \mathbf{EI}_{e,i,r}^{-\rho\mathbf{E}_{i,r}})^{-\mathbf{1}/\rho\mathbf{E}_{i,r}} \quad (3.2.6)$$

Again, by minimizing the costs:

$$\mathbf{Cost}_{e,i,r}(\mathbf{EI}_{e,i,r}) = \sum_{e=1}^{5} (\mathbf{1} + \mathbf{te}_{e,i,r}) \cdot \mathbf{P}_{e,r} \cdot \mathbf{EI}_{e,i,r} \quad (3.2.7)$$

subject to the budget constraint (3.2.6), we get the demand equation for each type of energy input (see appendix 5.6, equation 5.6.12), where $\mathbf{te}_{e,i,r}$ is the federal tax rate on each type of energy input *e* used by sector *i* of region *r*, $\mathbf{A}_{i,r}^{\mathbf{E}}$ is a shift parameter, $\gamma\mathbf{E}_{e,i,r}$ is the share parameter and $\sigma\mathbf{E}_{i,r}$ is the elasticity of substitution between different energy inputs used by each production sector. The elasticity of substitution between different energy inputs is equal to $\mathbf{1}/(\mathbf{1} + \rho\mathbf{E}_{i,r})$.

Treated at an aggregate level, firms receive income from sales of goods and transfers from the regional and federal government and the rest of the world, they purchase intermediate inputs, make wage payments, pay taxes on capital use, labour use and energy use, and save (see Appendix 5.6, equation 5.6.13).

3.2.3. Households

Households receive income from labour, a fixed share of the capital income, transfers from the regional and federal governments (including unemployment benefits) and make transfers to the rest of the world (see Appendix 5.6, equation 5.6.51).

Labour supply in each region $(\mathbf{LSR}_{r})$ is endogenously determined by the exogenously given time endowment $(\mathbf{TS}_{r})$, which is allocated over the labour supply and leisure $(\mathbf{C}_{L,r})$:

$$\mathbf{TS}_{r} = \mathbf{LSR}_{r} + \mathbf{C}_{L,r} \quad (3.2.8)$$

Households pay taxes on income to the regional and federal government and save a fixed fraction of (money) income (see Appendix 5.6, equation 5.6.4). Further,

households' budget devoted to consumption of commodities is given by the total income minus the taxes and savings (see Appendix 5.6, equation 5.6.52), while the extended budget also takes into account the value of leisure, valued at the regional-wide average net wage rate.

A schematic representation of households' decisions is given in figure 3.2.2.

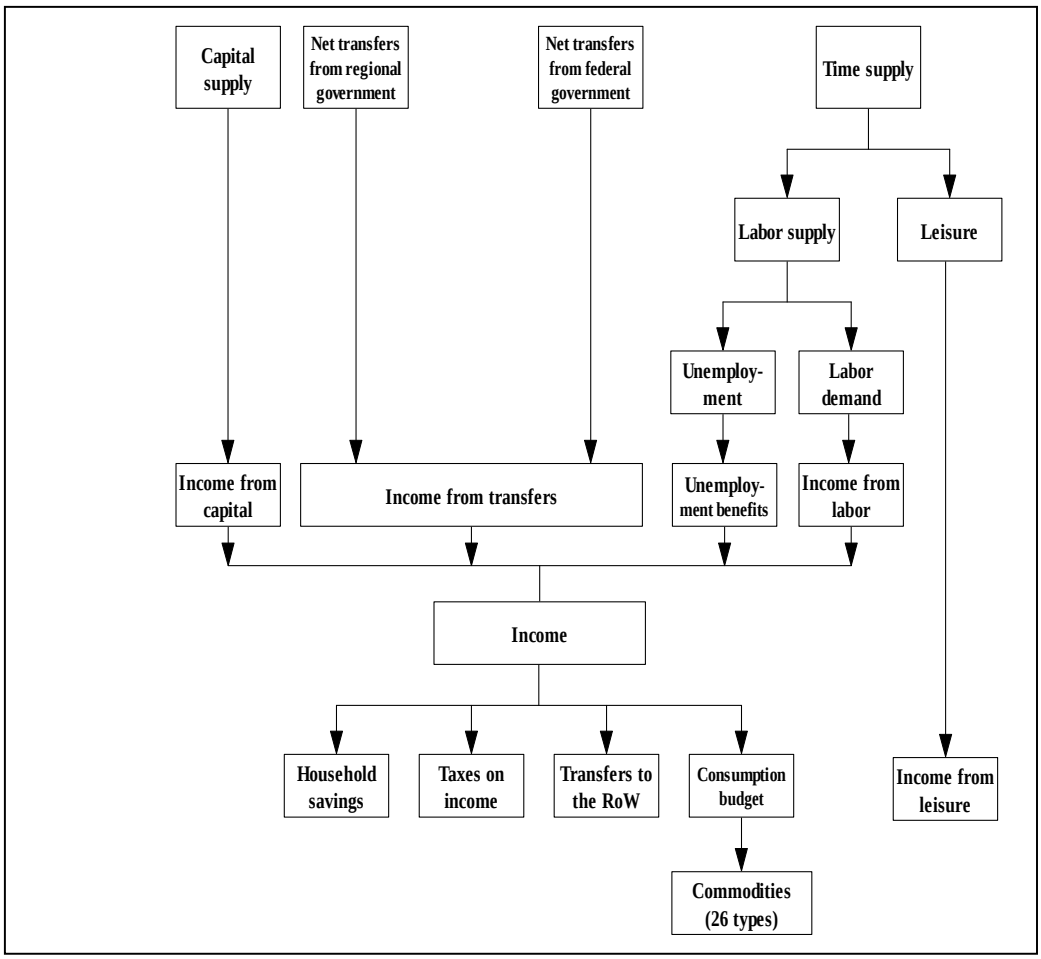

Figure 3.2.2. Decision structure of the households

The demand for commodities and for leisure is the result of a two-stage optimization procedure. In the first stage, the optimal allocation between a composite consumption commodity and leisure is given by maximizing a Stone-Geary utility function:

$$\mathbf{U(C_{c,r}, C_{L,r}) = (C_{c,r} - \mu H_{c,r})^{\alpha H_{c,r}} \cdot (C_{L,r} - \mu H_{L,r})^{\alpha H_{L,r}}} \quad (3.2.9)$$

subject to the budget constraint:

$$\mathbf{CEBUD_r = P_{c,r} \cdot C_{c,r} + (1 - ty_r - tyf_r) \cdot PL_r \cdot C_{L,r}} \quad (3.2.10)$$

where: $\alpha H_{c,r} + \alpha H_{L,r} = 1$

$\mathbf{C_{c,r}}$ represents the consumption of composite commodity of region *r*, $\mathbf{P_{c,r}}$ is the consumer price of the composite commodity of region *r*, $\mu_{c,r}$ and $\mu_{L,r}$ are the minimum (subsistence) levels of consumption of composite commodity and leisure[6] in

[6] In this case the subscript L stands for leisure.

region *r*, demanded by the households from the same region, and $\alpha \mathbf{H_{c,r}}$ and $\alpha \mathbf{H_{L,r}}$ are the income elasticities of the demand for the composite commodity and for leisure.

In the second stage, the optimal allocation between consumption commodities $\mathbf{(C_{i,r})}$ of the composite commodity is given by maximizing another Stone-Geary utility function:

$$\mathbf{U(C_{i,r}) = \prod_{i=1}^{26} (C_{i,r} - \mu H_{i,r})^{\alpha H_{i,r}}} \qquad (3.2.11)$$

subject to the budget constraint:

$$\mathbf{CBUD_r = \sum_{i=1}^{26} (1 + vat_{i,r} + tc_{i,r} + tcf_{i,r} - tsc_{i,r} - tscf_{i,r}) \cdot P_{i,r} \cdot C_{i,r}} \qquad (3.2.12)$$

where: $\sum_{i=1}^{26} \alpha \mathbf{H_{i,r}} = \mathbf{1}$

The consumer goods are distinguished in 26 categories, following the same classification as the one used for the production sectors. This classification is dictated by the level of disaggregation of the SAM, but it should not necessarily be the same with the classification of the production sectors. In our case it is assumed that each production sector produces one single type of commodity. Consumption is valued at consumer prices $\mathbf{(1 + vat_{i,r} + tc_{i,r} + tcf_{i,r} - tsc_{i,r} - tscf_{i,r}) \cdot P_{i,r}}$, which also incorporate value added tax $\mathbf{(vat_{i,r})}$, other regional $\mathbf{(tc_{i,r})}$ and federal $\mathbf{(tcf_{i,r})}$ consumption taxes, and regional $\mathbf{(tsc_{i,r})}$ and federal $\mathbf{(tscf_{i,r})}$ subsidies.

After some rearrangements, the two-stage optimization generates the demand equations (see Appendix 5.6, equations 5.6.1-5.6.3) for consumption commodities and the labour supply equation (the extended Linear Expenditure System)[7].

3.2.4. Government

Government behaviour is modelled at three different levels: federal, regional, and community. Both federal and regional tax systems are modelled in a detailed way. Furthermore, French Community behaviour is included in the model.

Regional governments

Tax revenues of each regional government $\mathbf{(TAXR_r)}$ consist of taxes on households' income, consumption taxes less subsidies, taxes on capital use, and taxes on production less subsidies (see Appendix 5.6, equation 5.6.18). Regional governments receive net transfers from the federal government $\mathbf{(TRFGF_r)}$, while the Walloon government also receives transfers from the French community $\mathbf{(TRGFC_{wal})}$. Furthermore, all three governments consume $\mathbf{(CGBUD_r)}$, make transfers to the firms $\mathbf{(TRFG_r)}$ and households $\mathbf{(TRHG_r)}$ from the same region and transfers to the rest of the world $\mathbf{(TRWG_r)}$, and save $\mathbf{(SG_r)}$:

$$\mathbf{CGBUD_r = TAXR_r + TRGFC_r \cdot INDEX_t + TRGFG_r \cdot INDEX_t - TRHG_r \cdot INDEX_t - TRFG_r \cdot INDEX_t - ER \cdot TRWG_r - SG_r \cdot INDEX_t} \qquad (3.2.13)$$

Transfers received from the federal government and the French community as well as the transfers to the households, firms and the savings are valued by using the regional

[7] The Linear Expenditure System (LES) was developed by Stone (1954) and represents a set of consumer demand equations linear in total expenditure.

Laspeyres consumer price index $(\mathbf{INDEX_r})$, while the transfers to the rest of the world are valued at the exchange rate $(\mathbf{ER})$.

The optimal consumption of commodities by the regional government is given by the maximization of a Cobb-Douglas utility function:

$$\mathbf{U(CG_{i,r})} = \prod_{\mathbf{i=1}}^{\mathbf{26}} \mathbf{CG_{i,r}}^{\alpha \mathbf{CG_{i,r_i}}} \tag{3.2.14}$$

subject to the budget constraint (3.2.13), with: $\sum_{\mathbf{i=1}}^{\mathbf{26}} \alpha \mathbf{CG_{i,r}} = \mathbf{1}$. The optimization process yields the demand equations for each type of commodity by region (see Appendix 5.6, equation 5.6.20).

Federal government

Tax revenues of the federal government $(\mathbf{TAXRF})$ include taxes on households' income (IPP), value added tax, excise taxes, other taxes less subsidies on consumption, taxes on capital, labour use and energy use, tariffs, taxes less subsidies on production. Furthermore, federal government consumes $(\mathbf{CFGBUD})$, makes transfers to the firms $(\mathbf{TRFFG_r})$, households $(\mathbf{TRHFG_r})$, regional governments $(\mathbf{TRGFG_r})$, French community $(\mathbf{TRFCFG})$ and the rest of the world $(\mathbf{TRWFG})$, and saves $(\mathbf{SFGT})$.

$$\begin{aligned}\mathbf{CFGBUD} = {} & \mathbf{TAXRF} - \mathbf{TRFCFG} \cdot \mathbf{CPI} - \mathbf{SFGT} \cdot \mathbf{CPI} - \mathbf{TRWFG} \cdot \mathbf{ER} - \\ & - \sum_{\mathbf{r=1}}^{\mathbf{3}} (\mathbf{TRFFG_r} \cdot \mathbf{INDEX_r} + \mathbf{TRHFG_r} + \mathbf{TRGFG_r} \cdot \mathbf{INDEX_r})\end{aligned} \tag{3.2.15}$$

Federal government transfers to the households of each region are composed of unemployment benefits $(\mathbf{trep_r} \cdot \mathbf{PL_r} \cdot \mathbf{UNEMP_r})$ and other transfers to the households $(\mathbf{TRO_r})$:

$$\mathbf{TRHFG_r} = \mathbf{trep_r} \cdot \mathbf{PL_r} \cdot \mathbf{UNEMP_r} + \mathbf{TRO_r} \cdot \mathbf{INDEX_r} \tag{3.2.16}$$

where $\mathbf{trep_r}$ is the replacement rate out of the regional-wide average wage rate and $\mathbf{UNEMP_r}$ is the unemployment rate by region.

Again, the optimal consumption of commodities by the federal government is given by the maximization of a Cobb-Douglas utility function:

$$\mathbf{U(CFG_{i,r})} = \prod_{\mathbf{i=1}}^{\mathbf{26}} \mathbf{CFG_{i,r}}^{\alpha \mathbf{CFG_{i,r_i}}} \tag{3.2.17}$$

subject to the budget constraint (3.2.15), with: $\sum_{\mathbf{i=1}}^{\mathbf{26}} \alpha \mathbf{CFG_{i,r}} = \mathbf{1}$. The optimization process yields the demand equation for federal government consumption for each type of commodity by region (see Appendix 5.6, equation 5.6.17).

French Community (Communauté Wallonie-Bruxelles)

French community receives transfers from the federal government and makes transfers to the Walloon government and further spends its disposable budget. The optimal consumption of commodities is given by the maximization of a Cobb-Douglas utility function, subject to the budget constraint, yielding the demand equations for each type of commodity by region (see Appendix 5.6, equation 5.6.22).

3.2.5. Inter-regional and foreign trade

The specification of foreign trade for each region is based on the small-country assumption, which means that the country is a price taker in both its imports and exports markets. As a result, both import prices and export prices are exogenously fixed in foreign currency (but are endogenous in domestic currency).

The assumption of imperfect substitution possibilities between domestically produced and imported goods, which goes back to Armington (1969), is now a standard feature of applied CGE models and will be adopted here as well. It indicates that domestic consumers use composite goods $(\mathbf{X_{i,r}})$ of imported and domestically produced goods, according to a CES function. Because we are dealing with a regional model, a distinction has to be made regarding the imports from the other regions $(\mathbf{ME_{i,rr+1,r}})$ and the imports from the rest of the world $(\mathbf{M_{i,r}})$. Therefore, the CES function pictures both the substitution possibilities between the domestically produced goods and the imports from the rest of the world and the substitution possibilities between the domestically produced goods $(\mathbf{XDD_{i,r}})$ and the imports from the other two regions:

$$\mathbf{X_{i,r}} = \mathbf{aA_{i,r}} \cdot [\gamma\mathbf{A1_{i,r}} \cdot \mathbf{M_{i,r}}^{-\rho\mathbf{A_{i,r}}} + \gamma\mathbf{A2_{i,r}} \cdot \mathbf{ME_{i,rr+1,r}}^{-\rho\mathbf{A_{i,r}}} + \gamma\mathbf{A3_{i,r}} \cdot \mathbf{ME_{i,rr+2,r}}^{-\rho\mathbf{A_{i,r}}} + \\ + (\mathbf{1} - \gamma\mathbf{A1_{i,r}} - \gamma\mathbf{A2_{i,r}} - \gamma\mathbf{A3_{i,r}}) \cdot \mathbf{XDD_{i,r}}^{-\rho\mathbf{A_{i,r}}}]^{-\mathbf{1}/\rho\mathbf{A_{i,r}}} \quad (3.2.18)$$

Minimizing the cost function:

$$\mathbf{Cost_{i,r}}(\mathbf{M_{i,r}}, \mathbf{ME_{i,rr+1,r}}, \mathbf{ME_{i,rr+2,r}}, \mathbf{XDD_{i,r}}) = \mathbf{PM_{i,r}} \cdot \mathbf{M_{i,r}} + \\ + \mathbf{PDM_{i,rr+1,r}} \cdot \mathbf{ME_{i,rr+1,r}} + \mathbf{PDM_{i,rr+2,r}} \cdot \mathbf{ME_{i,rr+2,r}} + \mathbf{PDD_{i,r}} \cdot \mathbf{XDD_{i,r}} \quad (3.2.19)$$

subject to (3.2.18), yields the demand equations for the imports from the rest of the world, the imports from the other two regions and domestically produced goods (see Appendix 5.6, equations 5.6.29-32), where $\mathbf{aA_{i,r}}$ is a shift parameter, $\gamma\mathbf{A1_{i,r}}$ and $\gamma\mathbf{A2_{i,r}}$ and $\gamma\mathbf{A3_{i,r}}$ are share parameters and the elasticity of substitution between imports and domestically produced goods $(\sigma\mathbf{A_{i,r}})$ is given by $\mathbf{1}/(\mathbf{1}+\rho\mathbf{A_{i,r}})$ for each region. $\mathbf{PM_{i,r}}$ is the price of imports from the rest of the world for sector *i* of region *r*, expressed in domestic currency, $\mathbf{PDM_{i,rr+1,r}}$ is the price of imports for sector *i* of region *r* from region *r+1*, $\mathbf{PDM_{i,rr+2,r}}$ is the price of imports for sector *i* of region *r* from region *r+2*, and $\mathbf{PDD_{i,r}}$ is the price of domestically produced goods for sector *i* in region *r*. It should be stressed that all three regions have the same currency, so that the prices of imports from the other two regions are already expressed in domestic currency. Furthermore, there are no tariffs between the Belgian regions.

Imperfect substitution is also assumed to exist between goods produced for the regional domestic market $(\mathbf{XDD_{i,r}})$ and for exports as captured by a constant elasticity of transformation (CET) function. Again a distinction should be made between the exports to the rest of the world and the exports to the other two Belgian regions:

$$\mathbf{XD_{i,r}} = \mathbf{aT_{i,r}} \cdot (\gamma\mathbf{T1_{i,r}} \cdot \mathbf{E_{i,r}}^{-\rho\mathbf{T_{i,r}}} + \gamma\mathbf{T2_{i,r}} \cdot \mathbf{EM_{i,r,rr+1}}^{-\rho\mathbf{T_{i,r}}} + \gamma\mathbf{T3_{i,r}} \cdot \mathbf{EM_{i,r,rr+2}}^{-\rho\mathbf{T_{i,r}}} + \\ + (\mathbf{1} - \gamma\mathbf{T1_{i,r}} - \gamma\mathbf{T2_{i,r}} - \gamma\mathbf{T3_{i,r}}) \cdot \mathbf{XDD_{i,r}}^{-\rho\mathbf{T_{i,r}}})^{-\mathbf{1}/\rho\mathbf{T_{i,r}}} \quad (3.2.20)$$

where $\mathbf{E_{i,r}}$ are the exports to the rest of the world, $\mathbf{EM_{i,r,rr+1}}$ are the exports to the first region, $\mathbf{EM_{i,r,rr+2}}$ are the exports to the second region, $\mathbf{aT_{i,r}}$ is a shift parameter, $\gamma\mathbf{T1_{i,r}}$ and $\gamma\mathbf{T2_{i,r}}$ and $\gamma\mathbf{T3_{i,r}}$ are share parameters, and the elasticity of substitution

$(\sigma \mathbf{T}_{i,r})$ between exports and domestically produced goods delivered to domestic market is given by $\mathbf{1}/(\mathbf{1}+\rho \mathbf{T}_{i,r})$ for each region.

By maximizing the revenue of the producer:

$$\mathbf{Revenue}_{i,r}(\mathbf{E}_{i,r},\mathbf{EM}_{i,r,rr+1},\mathbf{EM}_{i,r,rr+2},\mathbf{XDD}_{i+1}) = \mathbf{PE}_i \cdot \mathbf{E}_{i,r} + \mathbf{PDE}_{i,r,rr+1} \cdot \\ \cdot \mathbf{EM}_{i,r,rr+1} + \mathbf{PDE}_{i,r,rr+2} \cdot \mathbf{EM}_{i,r,rr+2} + \mathbf{PDD}_{i,r} \cdot \mathbf{XDD}_{i,r} \quad (3.2.21)$$

subject to (3.2.20) we derive the demand equations for exports and domestically produced goods (see Appendix 5.6, equations 5.6.24-27), where $\mathbf{PE}_i$ is the price of exports to the rest of the world of sector *i*[8], expressed in domestic currency, $\mathbf{PDE}_{i,r,rr+1}$ is the price of exports of sector *i* from region *r* to one of the Belgian regions *(r+1)*, $\mathbf{PDE}_{i,r,rr+2}$ is the price of exports of sector *i* from region *r* to the other region *(r+2)*.

The regional characteristic of the model imposes an additional restriction: the exports of one region to another region represent the imports of the second region from the first one (an obvious observation). For example, the exports of Wallonia to Brussels represent the imports of Brussels from Wallonia (see Appendix 5.6, equations 5.6.35-36). Because there are no taxes on imports and exports between the regions, the same equality stands for the prices (see Appendix 5.6, equations 5.6.33-34).

The balance of payments at the national level is further defined as all international incoming and outgoing payments, in foreign currency:

$$\mathbf{SWT} = \sum_{i=1}^{26}\sum_{r=1}^{3} \mathbf{PWEZ}_i \cdot \mathbf{E}_{i,r} - \sum_{i=1}^{26}\sum_{r=1}^{3} \mathbf{PWMZ}_i \cdot \mathbf{M}_{i,r} - \mathbf{TRWFG} + \\ - \sum_{r=1}^{3} (\mathbf{TRWG}_r + \mathbf{TRWH}_r - \mathbf{TRFW}_r - \mathbf{LW}_r \cdot \mathbf{PLWZ}_r) \quad (3.2.22)$$

The surplus or deficit of the balance of payments $(\mathbf{SWT})$, expressed in foreign currency, is determined by the difference between exports and imports, valued at world prices, $\mathbf{PWEZ}_i$ and $\mathbf{PWMZ}_i$ respectively, the transfers of the federal government, regional government and the households to the rest of the world and the demand for labour and the transfers received by the firms from the rest of the world. The surplus (deficit) of the balance of payments reflects the net lending (borrowing) of the economy to (from) the rest of the world.

3.2.6. Investment demand

As it is not possible to distinguish federal government savings and foreign savings at the regional level, total savings are derived at the national level $(\mathbf{S})$, and then allocated on different investment commodities by region. Total national savings are given by:

$$\mathbf{S} = \sum_{r=1}^{3} (\mathbf{SH}_r + \mathbf{SG}_r \cdot \mathbf{INDEX}_r + \mathbf{SF}_r) + \mathbf{SFGT} \cdot \mathbf{CPI} + \mathbf{SWT} \cdot \mathbf{ER} + \\ + \sum_{i=1}^{26}\sum_{r=1}^{3} \mathbf{DEP}_{i,r} \cdot \mathbf{P}_{i,r} \quad (3.2.23)$$

where $\mathbf{SH}_r$ are households' savings, $\mathbf{SG}_r$ regional governments' savings, $\mathbf{SF}_r$ firms savings, $\mathbf{SFGT}$ federal government' savings and $\mathbf{DEP}_{i,r}$ capital stock depreciation. Depreciation is modelled as a fixed share of capital stock (see Appendix 5.6, equation

[8] The price of exports to the rest of the world of sector *i*, expressed in domestic currency, is equal for all three regions because they have a common exchange rate and the international prices of imports are given by the external market.

5.6.39). $\mathbf{CPI}$ is the consumer price index at the national level, used to index the savings of the federal government.

Investments by type of commodity and region $(\mathbf{I_{i,r}})$ are modelled in a simple way, by maximizing a Cobb-Douglas utility function:

$$\mathbf{U(I_{i,r})} = \prod_{\mathbf{i=1}}^{\mathbf{26}} \prod_{\mathbf{r=1}}^{\mathbf{3}} \mathbf{I_{i,r}}^{\alpha \mathbf{I_{i,r}}} \tag{3.2.24}$$

subject to the budget constraint:

$$\mathbf{S} - \sum_{\mathbf{ix}} \sum_{\mathbf{r=1}}^{\mathbf{3}} \mathbf{SV_{ix,r}} \cdot \mathbf{P_{i,r}} - \sum_{\mathbf{im}} \sum_{\mathbf{r=1}}^{\mathbf{3}} \mathbf{SV_{im,r}} \cdot \mathbf{P_{i,r}} = \sum_{\mathbf{i=1}}^{\mathbf{26}} \sum_{\mathbf{r=1}}^{\mathbf{3}} \mathbf{I_{i,r}} \cdot \mathbf{P_{i,r}} \tag{3.2.25}$$

with $\sum_{\mathbf{i=1}}^{\mathbf{26}} \sum_{\mathbf{r=1}}^{\mathbf{3}} \alpha \mathbf{I_{i,r}} = \mathbf{1}$, where $\mathbf{SV_{ix,r}}$ and $\mathbf{SV_{im,r}}$ are the changes in stocks and $\mathbf{P_{i,r}}$ are the prices of the commodities (investment commodities) by sector and region. Changes in stocks are modelled in this case either as a fixed share out of gross output (see Appendix 5.6, equation 5.6.40) or as a share of imports from the rest of the world for the imported commodities which are not produced in Belgium (see Appendix 5.6, equation 5.6.41). Further, the maximization process yields the demand equations for investment by the type of commodity and region (see Appendix 5.6, equation 5.6.42).

3.2.7. Price equations

A common assumption for a CGE model, which has also been adopted here, is that economy is initially in equilibrium with the quantities normalized in such a way that prices equal unity. Due to the homogeneity the model only determines relative prices. Therefore, a particular price is selected to provide the numeraire price level against which all relative prices in the model will be measured. In this case, the consumer price index at the national level $(\mathbf{CPI})$ is chosen as the numeraire.

Different prices are distinguished for all producing sectors and regions, exports and imports. The domestic price of exports $(\mathbf{PE_i})$ is defined as the world price[9] $(\mathbf{PWEZ_i})$ times the exchange rate $(\mathbf{ER})$[10]. The domestic price of imports $(\mathbf{PM_{i,r}})$ is determined by the world price $(\mathbf{PWMZ_i})$, the exchange rate, and also by the tariffs rate $(\mathbf{tm_{i,r}})$. In this case, because the average tariffs rates with respect to the rest of the world are different in each Belgian region (because of the different composition of the import bundles for the same aggregate commodity), the prices of imports are differentiated by commodity and region (see Appendix 5.6, equation 5.6.28).

The price of the composite good i by region $(\mathbf{P_{i,r}})$ representing the CES aggregation of imports from the rest of the world $(\mathbf{M_{i,r}})$, imports from the other two regions ($\mathbf{ME_{i,rr+1,r}}$ and $\mathbf{ME_{i,rr+2,r}}$) and domestic goods supplied to the domestic market $(\mathbf{XDD_{i,r}})$ is given by[11]:

$$\mathbf{P_{i,r}} \cdot \mathbf{X_{i,r}} = \mathbf{PM_{i,r}} \cdot \mathbf{M_{i,r}} + \mathbf{PDM_{i,rr+1,r}} \cdot \mathbf{ME_{i,rr+1,r}} + \mathbf{PDM_{i,rr+2,r}} \cdot \mathbf{ME_{i,rr+r,r}} + \\ + \mathbf{PDD_{i,r}} \cdot \mathbf{XDD_{i,r}} \tag{3.2.26}$$

By adding the taxes and subsidies on consumption to the price of the composite good $(\mathbf{P_{i,r}})$, we get the consumer price of the domestically produced goods

[9] Due to the small-country assumption, the country is a price taker in both its imports and exports markets. As a result, both import prices and export prices are exogenously fixed. Because there are no taxes on exports, the domestic prices of exports are equal between regions for each type of commodity.

[10] See Appendix 5.6, equation 5.6.23.

[11] This is in fact the zero profit condition for the CES function.

$\mathbf{P_{i,r} \cdot (1 + vat_{i,r} + tc_{i,r} + tcf_{i,r} - tsc_{i,r} - tscf_{i,r})}$, which are used to determine consumer demand for commodities. The price of domestically produced goods $\mathbf{(PD_{i,r})}$, which are a CET aggregation of goods supplied to the domestic market $\mathbf{(XDD_{i,r})}$ and goods supplied to the other Belgian regions ($\mathbf{EM_{i,rr,r+1}}$ and $\mathbf{EM_{i,r,rr+2}}$) and to the rest of the world $\mathbf{(E_{i,r})}$, is given by[12]:

$$\mathbf{PD_{i,r} \cdot XD_{i,r} = PE_i \cdot E_{i,r} + PDE_{i,r,rr+1} \cdot EM_{i,r,rr+1} + PDE_{i,r,rr+2} \cdot EM_{i,r,rr+2} + PDD_{i,r} \cdot XDD_{i,r}} \quad (3.2.27)$$

Producer prices $\mathbf{(PD_{i,r})}$, prices for the capital-labour-energy bundle $\mathbf{(PKLE_{i,r})}$, capital-energy composite $\mathbf{(PKE_{i,r})}$ and energy bundle $\mathbf{(PEN_{i,r})}$ are given by the zero profit conditions (see Appendix 5.6, equations 5.6.55-58) associated to the nested production function (see Appendix 5.6, equation 5.6.8-12) for each sector and region.

Consumer price index is defined at both regional and national level in the model (see Appendix 5.6, equations 5.6.5-6). Laspeyres definition is used for all of them.

3.2.8. Labour market

Labour services are used by firms in the production process (see Appendix 5.6, equation 5.6.9). Commuters are also distinguished in the model as a fixed share of the total labour demand in the region they are employed. As a consequence, the households can earn their income in one region and spend it in a different one.

Labour market by region is closed by changes in unemployment:

$$\sum_{i=1}^{26} \mathbf{L_{i,wal}} = \mathbf{LSR_{wal} - shWBx} \cdot \sum_{i=1}^{26} \mathbf{L_{i,bxl} - shWFl} \cdot \sum_{i=1}^{26} \mathbf{L_{i,fla} - UNEMP_{wal}} \quad (3.2.28)$$

$$\sum_{i=1}^{26} \mathbf{L_{i,fla}} = \mathbf{LSR_{fla} - shFlBx} \cdot \sum_{i=1}^{26} \mathbf{L_{i,bxl} + shWFl} \cdot \sum_{i=1}^{26} \mathbf{L_{i,fla} - UNEMP_{fla}} \quad (3.2.29)$$

$$\sum_{i=1}^{26} \mathbf{L_{i,bxl}} = \mathbf{LSR_{bxl} + shWBx} \cdot \sum_{i=1}^{26} \mathbf{L_{i,bxl} + shFlBx} \cdot \sum_{i=1}^{26} \mathbf{L_{i,bxl} - UNEMP_{bxl}} \quad (3.2.30)$$

where $\mathbf{LSR_r}$ is the labour supply in each region, $\mathbf{shWBx}$ is the share of commuters from Wallonia to Brussels, $\mathbf{shWFl}$ is the share of commuters from Wallonia to Flanders, $\mathbf{shFlBx}$ is the share of commuters from Flanders to Brussels and $\mathbf{UNEMP_r}$ is regional unemployment. Subscripts $\mathbf{wal}$, $\mathbf{fla}$ and $\mathbf{bxl}$ stand for the three regions: Wallonia, Flanders and Brussels. Furthermore, total supply of labour to each region and the rest of the world $\mathbf{(LS_r)}$ is given by:

$$\mathbf{LS_r = LSR_r + LW_r} \quad (3.2.31)$$

where $\mathbf{LW_r}$ represents the demand of labour of the rest of the world from each region.

As already mentioned, the model allows for endogenous unemployment. The regional average wage rate paid by the firms is a function of regional consumer prices and the regional unemployment rate, as follows:

$$\mathbf{(PL_r / PLZ_r)/(INDEX_t / INDEXZ_t) - 1 = beta_r \cdot \cdot [(UNEMP_r / LSR_r)/(UNEMPZ_t / LSRZ_r) - 1]} \quad (3.2.32)$$

[12] Again, this represents the zero profit condition for the CET function.

where $\mathbf{PLZ_r}$ is the regional-wide average wage rate in the base year, $\mathbf{INDEXZ_r}$ is the regional consumer price index in the base year and $\mathbf{beta_r}$ is a parameter.

3.2.9. Market clearing equations

Equilibrium in the product, capital and labour markets requires that demand equals supply at the prevailing prices (taking into account unemployment for the labour market). For the supply and use of capital this means that the following equation must hold:

$$\sum_{i=1}^{26}(1-d_{i,r})\cdot K_{i,r} = KS_r \qquad (3.2.33)$$

where $\mathbf{KS_r}$ is the total capital stock by region and $\mathbf{d_{i,r}}$ is the depreciation rate by sector and region. Labour markets clearing equations by region have already been presented above (see equations 3.2.28-30).

Similarly, the sum of demand for non-energy intermediate inputs $\mathbf{(io_{ne,i,r})}$, of demand for government and households consumption, of demand for investment goods and inventories must equal the supply of the non-energy composite good *ne* of region *r* $\mathbf{(X_{ne,r})}$:

$$C_{ne,r} + I_{ne,r} + SV_{ne,r} + \sum_{i=1}^{26} io_{ne,i,r}\cdot XD_{i,r} + CG_{ne,r} + CFG_{ne,r} + CFC_{ne,r} = X_{ne,r} \qquad (3.2.34)$$

where $\mathbf{CG_{ne,r}}$ is the regional government consumption of non-energy commodities, $\mathbf{CFG_{ne,r}}$ is the federal government consumption of non-energy commodities and $\mathbf{CFC_{ne,r}}$ is the French community consumption of non-energy commodities. The supply of energy composite good $\mathbf{(X_{e,r})}$ should also equal the sum of demand for energy intermediate inputs $\mathbf{(EI_{e,i,r})}$, of demand for government and households consumption, of demand for investment goods and inventories:

$$C_{e,r} + I_{e,r} + SV_{e,r} + \sum_{i=1}^{26} EI_{e,i,r} + CG_{e,r} + CFG_{e,r} + CFC_{e,r} = X_{e,r} \qquad (3.2.35)$$

3.2.10. CO_2 emissions

CO_2 emissions by sector and region $\mathbf{(CO2EMIS_{i,r})}$, measured in kilos, are derived as:

$$CO2EMIS_{i,r} = \sum_{e=1}^{5} CO2GJ_{e,i,r}\cdot GJOULE_{e,r}\cdot(X_{e,r} - SV_{e,r})\cdot CO2SCAL_{i,r} \qquad (3.2.36)$$

where $\mathbf{CO2GJ_{e,i,r}}$ represents the kilos of CO_2 emissions per Giga joule out of energy input *e*, used by sector *i* of region *r*, $\mathbf{GJOULE_{e,r}}$ is a conversion factor for energy inputs from value terms in Giga joules and $\mathbf{CO2SCAL_{i,r}}$ is a scaling factor which assures the consistency with the CO_2 emissions provided by the Interregional Cell for the Environment[13] for 1997.

3.2.11. Closure rules

The closure rule refers to the manner in which demand and supply of commodities, the macroeconomic identities and the factor markets are equilibrated ex-post. Due to

[13] The CO2 emissions provided by the Interregional Cell for the Environment follow the guidelines of the United Nation Framework Convention on Climate Change (UNFCCC).

the complexity of the model, a combination of closure rules is needed. The particular set of closure rules should also be consistent, to the largest extent possible, with the institutional structure of the economy and with the purpose of the model.

To balance the number of endogenous variables and the number of independent equations in the model, additional assumptions are needed. Therefore, the transfers between the regional and federal government, households, firms and the rest of the world, for each region, are exogenously fixed in real terms. Further, in order to achieve the clearing of the labour and capital markets for each region, inter-sectoral mobility of both labour and capital is assumed. However, in the labour market the presence of unemployment introduces rigidities. The unemployment is endogenously determined through a wage curve. Labour supply is endogenously determined by fixing the time endowment for each region. In the capital market the regional supply of capital stock is exogenously fixed. Inter-sectoral rental rate differentials further introduce rigidities on the regional capital markets.

The most widely accepted macro closure rule for CGE models implies the assumption that investment and savings balance. In the model, the investment is assumed to adjust to the available domestic and foreign savings. This reflects an economy in which savings form a binding constraint. The interest rate is assumed to effectively balance the supply and demand for investments, even if the specific mechanism is not incorporated in the model. This macro closure rule is neoclassical in spirit. However, the fact that the model allows for unemployment introduces a Keynesian element. As already mentioned, in models of this size it is not uncommon that a few closure rules are combined to get as close as possible to a realistic representation of the economy.

The federal and regional governments' behaviour is modelled through an optimization process, which yields the optimal allocation of governments consumption by type of commodity and region. The budget deficit or surplus of federal and regional governments are exogenously fixed in real terms. For the external sector, the balance of payments balance is fixed and the endogenous exchange rate brings the balance of payments into equilibrium.

According to Walras' law if (n-1) markets are cleared the n^{th} one is cleared as well. Therefore, in order to avoid over-determination of the model, balance of payments equation (equation 3.2.22) has been dropped. However, the system of equations guarantees, through Walras' law, that its balance is equal to the difference between the exports and imports and the transfers from and to the rest of the world.

3.2.12. Incorporation of dynamics

GreenMod has a recursive dynamic structure composed of a sequence of several temporary equilibria. Recursive sequence equilibrium approach assumes that in each time period, the model is solved for an equilibrium, given the exogenous conditions assumed for that particular period. In between periods, stock variables are updated as a result of the equilibrium outcomes of the preceding period (e.g. investment demand leading to an increased capital stock in the next period) and exogenously for some variables (e.g. population). The growth path for the economy is reflected by a set of linked equilibria, where the connection is provided by capital accumulation and population growth. The current equilibrium is only dependent on the previous equilibrium. The simulation horizon of the model is set at 25 years but can easily be extended in a flexible way. The model is solved dynamically with annual steps.

3.3. Tradable pollution permits

The tasks related to the tradable pollution permits were carried out by our partners from the Center for Operations Research & Econometrics (CORE) of the Catholic University of Louvain. One contribution of CORE during the first year of the GreenMod project was to present to the non-specialised reader a set of possible models of permit

markets. Beside the perfectly competitive Walrasian market, we consider alternative models that are likely to affect the market's efficiency in terms of abatement cost minimisation.

The different models that will be considered here are the following:

- market power (of a polluting firm)
- presence of market makers
- transaction costs
- multiple pollutants
- possibility of banking
- auctions
- uncertainty and financial products
- enforcement costs.

To facilitate the reading, the models considered are presented in a simple unified framework, while limiting technical considerations to the essential. There are N firms producing different goods with a single input (for example energy). As a by-product production leads to emissions of a certain pollutant (for example CO2). Each firm receives freely a given quantity of pollution permits that are tradable. A firm cannot emit more than the quantity of permits in its possession. Each firm chooses its production level (or equivalently its holding of permits) so as to maximise its profit, which is equal to production plus the difference between the quantities of permits received and consumed in value. The equilibrium price of permits is such that the aggregate excess demand of permits is zero.

3.3.1. Market power

In the case of a firm with market power, there is no more equality between the price of permits and the marginal productivity of the polluting input, unless this firm receives exactly the number of permits it will consume at equilibrium. Except this particular case, the market is inefficient and the inefficiency is proportional to the difference between the quantities of permits received and consumed by the firm with market power.

3.3.2. Market makers

In the presence of markets makers acting as financial intermediaries between firms buying and selling permits, a spread between 'ask' and 'bid' prices may occur. These 'ask' and 'bid' prices surround the Walrasian price. The market is inefficient because the marginal cost of the supplying firms (equal to the bid price) is not equal to the marginal cost of the demanding firms (equal to the ask price).

3.3.3. Transaction costs

The case where the trade of permits is affected by transaction costs is similar to the preceding case. The market is inefficient because the marginal cost of the supplying firms is not equal to the marginal cost of the demanding firms. The quantity of

exchanged permits is lower than in the case of a Walrasian market (i.e. without transaction costs).

3.3.4. Multiple pollutants

In the presence of several pollutants, two cases are possible. If it is possible to express these pollutants in terms of one of them chosen as reference (as it is the case for GHG expressed in CO2-equivalent), only one market of permits is sufficient. If the market is perfectly competitive, abatement marginal costs are equalised between firms and between gases. In the case where a market of permits is organised for each pollutant, each firm equalises the marginal productivity of each pollutant to the price of the corresponding permit. Thus the marginal productivities of the pollutants may not equalise.

3.3.5. Banking of permits

In a multi-period model, one may introduce the possibility of banking. In a two-period model where banking is possible (but no borrowing), the equilibrium prices of the two periods will depend of the relative quantities of permits issued. Because of intertemporal arbitrage, the price of period 1 must be higher or equal to the price of period 2. Two cases are possible. If the quantity of permits issued in period 1 is sufficiently low with respect to the quantity of period 2, price of period 1 is higher than the price of period 2 and there is no banking. If not, prices of permits are equal, i.e. marginal abatement costs equalise between periods and banking is positive.

3.3.6. Auctions

If environmental regulation is primarily aimed at minimising polluters' expenses while improving environmental quality, then free distribution of permits merit serious consideration. But if polluters' payments for permits are not viewed as a problem or are viewed as a policy goal, certain types of auctions should be considered. A simple form of auction is the 'uniform-pricing' static auction, where all permits are sold for a single clearing price. This type of auction allows strategic behaviour of polluters, but this is not a problem when these ones are numerous.

3.3.7. Uncertainty and derivatives

When deciding the extent of abatement measures, a firm may be uncertain about the price of permits. A risk averse firm may cover itself against price uncertainty by purchasing derivatives such as futures, forwards or options, if markets for such financial products exist of course. In such a framework the firm chooses the level of pollution reduction and its portfolio of permits and derivatives so as to maximise the expectation of a concave function of its profit. The equilibrium price of a certain derivative is such that the aggregate excess demand for this product is zero.

3.3.8. Enforcement costs

If there is no control from the public authority, a firm could be tempted to cheat, by polluting more than its holding of permits. To reduce the risk of non-compliance, the regulator can design a system of control and sanctions, but if the polluters are numerous, this system would be very expensive if the control is complete. In practice control will therefore be incomplete and random. In such a framework, the firm has to chose between complying with no risk of penalty, and polluting more than allowed with a probability less than 1 to be sanctioned. As in the case of transaction costs the possibility of fraud may affect the efficiency of the market of permits.

Another contribution of the CORE team during this first period was to survey the applied economic models used to evaluate the impacts and the functioning of GHG tradable markets. This part of the research encompasses a detailed analysis of the modelling of permits within these models and a comparison and interpretation of the results carried out with these models.

The models considered in this survey are the most influential used today at European and worldwide levels: AIM, G-CUBED, GTEM, Merge, WorldScan and MIT-EPPA. The question addressed from the modelling point of view was whether theses applied models were able to capture the theoretical features describes above, notably the multi-gas and banking.

Naturally, during this research period, special attention has been paid to the UK auctions launched in April 2002 and, of course, to the forthcoming European Union trading scheme expected to come into force in January 2005. The policy options and the (non) compatibility between the two schemes have been screened. The potential interactions raise a set of generic issues. For example, the Commission may prevent trading between the two trading systems owing to concerns about non-CO2 gases, hot air and double crediting. This would leave the UK market relatively small. Such a feature should be considered in the applied modelling frameworks.

4. PLANNING FOR 2003

The first year of the project was devoted to data collection, the development of a detailed sectoral and regional database for Belgium, the construction of a simplified version of the model GreenMod and its implementation on the software GAMS, and finally to the review of the literature regarding tradable pollution permits. All these tasks have been successfully carried out. We have accomplished building the multi-regional and multi-sectoral database as well as a simplified, static version of the model.

During the second year of the project the Belgian multi-regional and multi-sectoral database will be integrated within an aggregated version of the international database GTAP (version 5). Secondly, the first version of the model currently operational will be developed into a full version covering all three Belgian regions as well as all the main economies of the world. This version will cover the permit markets at the Belgian, European and international markets. Once, the recursively dynamic version is fully tested and finalised, we will use it for policy analysis. Policy simulations will be discussed and agreed upon with the institutions represented in the Users' Committee and the OSTC.

Below, we provide the tasks of our work plan for 2003.

Step/Task 1: Start from the current version of the model and disaggregate the household block into 10 household-types (to be used for distributional analysis of environmental policies).

Step/Task 2: Aggregation of the sectors and the countries/regions in the GTAP database version 5 to the level of disaggregation in GreenMod.

Step/Task 3: Merge the Belgian multi-regional social accounting matrices with the international database with full sectoral bilateral trade and investment flows.

Step/Task 4: Develop the multi-regional, multi-national, multi-sectoral static version of the model, write the GAMS code and calibrate it on the full database developed in Task 3. Test the model, correct the bugs, and proceed with the final adjustments.

Step/Task 5: Introduce the tradable permit market (at the regional and international levels) with flexibility on the choice of the sectors and/or regions to include.

Step/Task 6: Build the recursively dynamic version of the full model (including dynamics in the permit market and assessment of the different operational modes of the market such as: methods of assignment and life span of the permits, monitoring and penalties, gradually more restrictive quotas, etc)

Step/Task 7: Definition and implementation of the baseline simulation.

Step/Task 8: Dynamic re-calibration following the baseline simulation.

Step/Task 9: Sensitivity analysis.

Step/Task 10: Run policy simulations and sensitivity analysis.

Step/Task 11: Write the final report and the user's guide

5. ANNEXES

5.1. References

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5.2. Regional data on energy and environment

	Energy transformation (electricity power plants)	All industries	Iron and steel	Steel industry	Integrated companies	Other industries	Non-ferrous	Chemical industries	Food, beverage and tobacco	Food industries	Food industries and tobacco products	Publishing companies	Paper companies	Publishing and paper companies
Coal	W - F	F	F	W	W			F	F			F		
Coke	W	F	F	W	W		F	F	F	W				
Lignite														
Terrill tar fuel	W													
Oil	W			W	W		W	W		W			W	
LPG		F						F - W	F					
Gasoline														
Gasses and diesel		F					F	F	F			F		
Propane butane														
Propane butane LPG														
Heavy fioul	W - F	F - B	F	W	W		F	F	F	W	B	F	W	B
Light fioul	B	B						B			B			B
Oil coke				W										
Other oil products		F		W			W	F - W		W			W	
Oil products														
Natural Gaz	W - B - F	F - B	F				F	F - B	F		B	F		B
Natural gaz distrigaz				W	W		W	W		W			W	
Natural Gaz, public distribution				W	W		W	W		W			W	
Gas from coke furnace	W	F	F	W	W									
Gaz from furnace	W - F	F	F	W	W									
Other combustible		F						F						
Recuperation and renewable energ.	W - B													
Electricity	W - B	F	F				F	F	F			F		
High tension electricity								B			B			B
Bought electricity				W	W		W	W		W			W	
Auto-production electricity				W	W			W		W			W	
Nuclear combustible	W													
Heat		F												
Nuclear heat	F													
Steam	B													
Steam - heat	W													
Bought steam								W		W			W	
Auto-produced steam				W	W	W		W		W			W	

Note : a W indicates that the value for Wallonia is available, a B for Brussels and a F for Flanders
Source : Vito for Flanders, IBGE and Institut Wallon for Brussels, DGRNE et Institut Wallon for Wallonia

	Non metallic mineral products	Cement	Limes, tiled floor, dolomie	Glass	Other non metallic minerals	Metallic and non-metallic minerals	Metallic transformation industries	Manufacture of fabricated metal products	Manufacture of textile, leather and clothing	Textile	Other manufactures	Housing and equivalent	Housing	Tertiary sector, shops and administrations
Coal	F - W	W	W							W		F	W - B	
Coke	W	W			W		F	W					W	
Lignite	W		W											
Terrill tar fuel	W	W												
Oil	W	W	W	W	W			W		W	W			
LPG											F	F		F
Gasoline														
Gasses and diesel	F						F		F		F	F		F
Propane butane														
Propane butane LPG														
Heavy fioul	F - W	W	W	W	W		F	W	F	W	F - W	F		F
Light fioul						B		B					B	
Oil coke	W	W	W											
Other oil products	W		W	W	W			W		W	F - W	F	B	
Oil products													W	
Natural Gaz	F					B	F	B	F		F	F	W - B	F
Natural gaz distrigaz	W	W	W	W	W			W			W			
Natural Gaz, public distribution	W	W		W	W			W		W	W			
Gas from coke furnace														
Gaz from furnace														
Other combustible											F	F		F
Recuperation and renewable energ.														
Electricity	F						F		F		F	F	W - B	F
High tension electricity						B		B						
Bought electricity	W	W	W	W	W			W		W	W			
Auto-production electricity								W			W			
Nuclear combustible														
Heat												F		
Nuclear heat														
Steam														
Steam - heat													W	
Bought steam								W		W	W			
Auto-produced steam								W			W			

Note : a W indicates that we have the value for Wallonia, a B for Brussels and a F for Flanders

Source : Vito for Flanders, IBGE and Institut Wallon for Brussels, DGRNE et Institut Wallon for Wallonia

	Households	Shops	Wholesale trade and commercial intermediates	Retail trade (without supermarkets)	Supermarkets	Hotel, restaurants and cafés	Hotels and restaurants	Agriculture, forestry and fishing	Agriculture	Transport	Road	Rail	Air
Coal	**F**							**F**					
Coke													
Lignite													
Terrill tar fuel													
Oil											**W**		
LPG	**F**									**F**	**F - W**		
Gasoline										**F - B**	**F - W- B**		**F**
Gasses and diesel	**F**							**F**		**F**	**F**	**F**	
Propane butane		**W**	**W**	**W**		**W**							
Propane butane LPG			**F**				**F**						
Heavy fioul		**F - W - B**	**W - B**				**F**	**F**					
Light fioul		**F - W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**F**			**B**	**B**	**B**	
Oil coke													
Other oil products		**B**	**B**					**F**			**B**		
Oil products									**W**			**W**	**W**
Natural Gaz	**F**	**F - W - B**	**W - B**	**W - B**	**W - B**	**W - B**		**F**		**F**	**B**		
Natural gaz distrigaz													
Natural Gaz, public distribution													
Gas from coke furnace													
Gaz from furnace													
Other combustible	**F**												
Recuperation and renewable energ.													
Electricity	**F**	**F**						**F**	**W**	**F**		**F - B**	
High tension electricity		**W**	**W - B**	**W - B**	**W - B**	**W - B**							
Bought electricity													
Auto-production electricity													
Nuclear combustible													
Heat													
Nuclear heat													
Steam													
Steam - heat													
Bought steam													
Auto-produced steam													

Note : a W indicates that we have the value for Wallonia, a B for Brussels and a F for Flanders
Source : Vito for Flanders, IBGE and Institut Wallon for Brussels, DGRNE et Institut Wallon for Wallonia

	Inland water transport	Pipeline transportation	Transport and communication	Railroad (SNCB)	Public transportation (without SNCB)	Private transportation	Post and telecommunication	Banks and insurances	Education	Health and social work activities	Public and international administrations	International organizations	Offices and administration
Coal													
Coke													
Lignite													
Terrill tar fuel													
Oil													
LPG													
Gasoline													
Gasses and diesel	**F**												
Propane butane									**W**	**W**			
Propane butane LPG									**F**	**F**			**F**
Heavy fioul									**F - W**	**F - W**			**F**
Light fioul	**B**		**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**F - W - B**	**F - W - B**	**W - B**	**W - B**	**F**
Oil coke													
Other oil products										**B**			
Oil products	**W**												
Natural Gaz		**F**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**F - W - B**	**F - W - B**	**W - B**	**W - B**	
Natural gaz distrigaz													
Natural Gaz, public distribution													
Gas from coke furnace													
Gaz from furnace													
Other combustible													
Recuperation and renewable energ.													
Electricity									**F**	**F**			**F**
High tension electricity			**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	**W - B**	
Bought electricity													
Auto-production electricity													
Nuclear combustible													
Heat													
Nuclear heat													
Steam													
Steam - heat			**W**				**W**	**W**	**W**	**W**	**W**		
Bought steam													
Auto-produced steam													

Note : a W indicates that we have the value for Wallonia, a B for Brussels and a F for Flanders
Source : Vito for Flanders, IBGE and Institut Wallon for Brussels, DGRNE et Institut Wallon for Wallonia

5.3. Template for regional social accounting matrix

			Commodities									**Activities**								
			Agricultural			Industrial			Private services			Agriculture			Industry			Private services		
			Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre
Commodities	Agricultural	Wallonie										IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}
		Bruxelles										IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}
		Flandre										IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}
	Industrial	Wallonie										IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}
		Bruxelles										IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}
		Flandre										IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}
	Private services	Wallonie										IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}	IO_{WW}	IO_{WB}	IO_{WF}
		Bruxelles										IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}	IO_{BW}	IO_{BB}	IO_{BF}
		Flandre										IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}	IO_{FW}	IO_{FB}	IO_{FF}
Activities	Agriculture	Wallonie	XDD_{WW}	EM_{WB}	EM_{WF}															
		Bruxelles	EM_{BW}	XDD_{BB}	EM_{BF}															
		Flandre	EM_{FW}	EM_{FB}	XDD_{FF}															
	Industry	Wallonie				XDD_{WW}	EM_{WB}	EM_{WF}												
		Bruxelles				EM_{BW}	XDD_{BB}	EM_{BF}												
		Flandre				EM_{FW}	EM_{FB}	XDD_{FF}												
	Private services	Wallonie							XDD_{WW}	EM_{WB}	EM_{WF}									
		Bruxelles							EM_{BW}	XDD_{BB}	EM_{BF}									
		Flandre							EM_{FW}	EM_{FB}	XDD_{FF}									
Factors	Capital	Wallonie										K_{WW}			K_{WW}			K_{WW}		
		Bruxelles											K_{BB}			K_{BB}			K_{BB}	
		Flandre												K_{FF}			K_{FF}			K_{FF}
	Labor	Wallonie										L_{WW}	L_{WB}	L_{WF}	L_{WW}	L_{WB}	L_{WF}	L_{WW}	L_{WB}	L_{WF}
		Bruxelles										L_{BW}	L_{BB}	L_{BF}	L_{BW}	L_{BB}	L_{BF}	L_{BW}	L_{BB}	L_{BF}
		Flandre										L_{FW}	L_{FB}	L_{FF}	L_{FW}	L_{FB}	L_{FF}	L_{FW}	L_{FB}	L_{FF}
Institutional sectors	Firms	Wallonie																		
		Bruxelles																		
		Flandre																		
	Households	Wallonie																		
		Bruxelles																		
		Flandre																		
	Government	Wallonie																		
		Bruxelles																		
		Flandre																		
		Federal																		
Other accounts	Taxes on commodities (VAT tax)	Wallonie	TRV_W			TRV_W			TRV_W											
		Bruxelles		TRV_B			TRV_B			TRV_B										
		Flandre			TRV_F			TRV_F			TRV_F									
	Taxes on commodities (excises)	Wallonie	TRE_W			TRE_W			TRE_W											
		Bruxelles		TRE_B			TRE_B			TRE_B										
		Flandre			TRE_F			TRE_F			TRE_F									
	Taxes on capital	Wallonie										TRK_W			TRK_W			TRK_W		
		Bruxelles											TRK_B			TRK_B			TRK_B	
		Flandre												TRK_F			TRK_F			TRK_F

	Taxes on labor	Wallonie				TRL_W	TRL_W	TRL_W
		Bruxelles				TRL_B	TRL_B	TRL_B
		Flandre				TRL_F	TRL_F	TRL_F
	Taxes on production	Wallonie				TRP_W	TRP_W	TRP_W
		Bruxelles				TRP_B	TRP_B	TRP_B
		Flandre				TRP_F	TRP_F	TRP_F
	Taxes on househ income	Wallonie						
		Bruxelles						
		Flandre						
Other accounts	Corporate taxes	Wallonie						
		Bruxelles						
		Flandre						
	Tarrifs	Wallonie	TRM_W	TRM_W	TRM_W			
		Bruxelles	TRM_B	TRM_B	TRM_B			
		Flandre	TRM_F	TRM_F	TRM_F			
	Subsidies on commodities	Wallonie	$TRCS_W$	$TRCS_W$	$TRCS_W$			
		Bruxelles	$TRCS_B$	$TRCS_B$	$TRCS_B$			
		Flandre	$TRCS_F$	$TRCS_F$	$TRCS_F$			
		Federal	$TRCS_{FED,W}$ $TRCS_{FED,B}$ $TRCS_{FED,F}$	$TRCS_{FED,W}$ $TRCS_{FED,B}$ $TRCS_{FED,F}$	$TRCS_{FED,W}$ $TRCS_{FED,B}$ $TRCS_{FED,F}$			
	Subsidies on production	Wallonie				$TRPS_W$	$TRPS_W$	$TRPS_W$
		Bruxelles				$TRPS_B$	$TRPS_B$	$TRPS_B$
		Flandre				$TRPS_F$	$TRPS_F$	$TRPS_F$
		Federal				$TRPS_{FED,W}$ $TRPS_{FED,B}$ $TRPS_{FED,F}$	$TRPS_{FED,W}$ $TRPS_{FED,B}$ $TRPS_{FED,F}$	$TRPS_{FED,W}$ $TRPS_{FED,B}$ $TRPS_{FED,F}$
Rest of the World			EM_{RoWW} EM_{RoWB} EM_{RoWF}	EM_{RoWW} EM_{RoWB} EM_{RoWF}	EM_{RoWW} EM_{RoWB} EM_{RoWF}			
Changes in stocks		Wallonie						
		Bruxelles						
		Flandre						
Savings-Investment		Wallonie				$DEPR_W$	$DEPR_W$	$DEPR_W$
		Bruxelles				$DEPR_B$	$DEPR_B$	$DEPR_B$
		Flandre				$DEPR_F$	$DEPR_F$	$DEPR_F$
Total			Total supply of commodities (domesticaly produced and imported)			Net outlays of the production sectors		

Factors						Institutional accounts										Other accounts								
Capital			Labor			Firms			Households			Government				Taxes on commodities(VAT tax)			Taxes on commodities(excises)			Taxes on capital		
Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Federal	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre
									C_{WW}	C_{WB}	C_{WF}	CG_{WW}	CG_{WB}	CG_{WF}	$CG_{FED,W}$									
									C_{BW}	C_{BB}	C_{BF}	CG_{BW}	CG_{BB}	CG_{BF}	$CG_{FED,B}$									
									C_{FW}	C_{FB}	C_{FF}	CG_{FW}	CG_{FB}	CG_{FF}	$CG_{FED,F}$									
									C_{WW}	C_{WB}	C_{WF}	CG_{WW}	CG_{WB}	CG_{WF}	$CG_{FED,W}$									
									C_{BW}	C_{BB}	C_{BF}	CG_{BW}	CG_{BB}	CG_{BF}	$CG_{FED,B}$									
									C_{FW}	C_{FB}	C_{FF}	CG_{FW}	CG_{FB}	CG_{FF}	$CG_{FED,F}$									
									C_{WW}	C_{WB}	C_{WF}	CG_{WW}	CG_{WB}	CG_{WF}	$CG_{FED,W}$									
									C_{BW}	C_{BB}	C_{BF}	CG_{BW}	CG_{BB}	CG_{BF}	$CG_{FED,B}$									
									C_{FW}	C_{FB}	C_{FF}	CG_{FW}	CG_{FB}	CG_{FF}	$CG_{FED,F}$									
												KG_{WW}			$KG_{FED,W}$									
													KG_{BB}		$KG_{FED,B}$									
														KG_{FF}	$KG_{FED,F}$									
												LG_{WW}	LG_{WB}	LG_{WF}	$LG_{FED,W}$									
												LG_{BW}	LG_{BB}	LG_{BF}	$LG_{FED,B}$									
												LG_{FW}	LG_{FB}	LG_{FF}	$LG_{FED,F}$									
KSF_W												$TRGF_{WW}$			$TRG_{FED}F_W$									
	KSF_B												$TRGF_{BB}$		$TRG_{FED}F_B$									
		KSF_F												$TRGF_{FF}$	$TRG_{FED}F_F$									
KSH_W			LSH_{WW}	LSH_{WB}	LSH_{WF}	$TRFH_{WW}$	$TRFH_{WB}$	$TRFH_{WF}$				$TRGH_{WW}$			$TRG_{FED}H_W$									
	KSH_B		LSH_{BW}	LSH_{BB}	LSH_{BF}	$TRFH_{BW}$	$TRFH_{BB}$	$TRFH_{BF}$					$TRGH_{BB}$		$TRG_{FED}H_B$									
		KSH_F	LSH_{FW}	LSH_{FB}	LSH_{FF}	$TRFH_{FW}$	$TRFH_{FB}$	$TRFH_{FF}$						$TRGH_{FF}$	$TRG_{FED}H_F$									
																$TRVG_{WW}$			$TREG_{WW}$			$TRKG_{WW}$		
																	$TRVG_{BB}$			$TREG_{BB}$			$TRKG_{BB}$	
																		$TRVG_{FF}$			$TREG_{FF}$			$TRKG_{FF}$

			TRH_W TRH_B TRH_F				
		TRF_W TRF_B TRF_F					
KS_{RoWW} KS_{RoWB} KS_{RoWF}	LS_{RoWW} LS_{RoWB} LS_{RoWF}	TRF_{RoWW} TRF_{RoWB} TRF_{RoWF}		TRG_{RoWW} TRG_{RoWB} TRG_{RoWF} $TRG_{RoW,FED}$			
		SF_{WW} SF_{BB} SF_{FF}	SH_{WW} SH_{BB} SH_{FW}	SG_{WW} $SG_{FED,W}$ SG_{BB} $SG_{FED,B}$ SG_{FF} $SG_{FED,F}$			
Capital outlays	Labor outlays	Firms outlays	Households outlays	Government outlays	Taxes on commodities (VAT tax)	Taxes on commodities (excises)	Taxes on capital

Other accounts																								
Taxes on labor			Taxes on production			Taxes on househ income			Corporate taxes			Tarrifs			Subsidies on commodities				Subsidies on production			
Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	Federal	Wallonie	Bruxelles	Flandre	Federal
$TRLG_{WW}$			$TRPG_{WW}$			$TRHG_{WW}$			$TRFG_{WW}$			$TRMG_{WW}$			$TRCSG_{WW}$				$TRPSG_{WW}$			
	$TRLG_{BB}$			$TRPG_{BB}$			$TRHG_{BB}$			$TRFG_{BB}$			$TRMG_{BB}$			$TRCSG_{BB}$				$TRPSG_{BB}$		
		$TRLG_{FF}$			$TRPG_{FF}$			$TRHG_{FF}$			$TRFG_{FF}$			$TRMG_{FF}$			$TRCSG_{FF}$				$TRPSG_{FF}$	
																		$TRCSG_{FED}$				$TRPSG_{FED}$

Taxes on labor	Taxes on production	Taxes on households income	Corporate taxes	Tarrifs	Subsidies on commodities	Subsidies on production

Rest of the World	**Changes in stocks**			**Savings-Investment**			**Total**
	Wallonie	Bruxelles	Flandre	Wallonie	Bruxelles	Flandre	
	SV_{WW}			I_{WW}	I_{WB}	I_{WF}	Total demand of commodities
		SV_{BB}		I_{BW}	I_{BB}	I_{BF}	
			SV_{FF}	I_{FW}	I_{FB}	I_{FF}	
	SV_{WW}			I_{WW}	I_{WB}	I_{WF}	
		SV_{BB}		I_{BW}	I_{BB}	I_{BF}	
			SV_{FF}	I_{FW}	I_{FB}	I_{FF}	
	SV_{WW}			I_{WW}	I_{WB}	I_{WF}	
		SV_{BB}		I_{BW}	I_{BB}	I_{BF}	
			SV_{FF}	I_{FW}	I_{FB}	I_{FF}	
EM_{WRoW} EM_{BRoW} EM_{FRoW}							
EM_{WRoW} EM_{BRoW} EM_{FRoW}							Gross output delivered to the domestic market and exported
EM_{WRoW} EM_{BRoW} EM_{FRoW}							
K_{WRoW} K_{BRoW} K_{FRoW}							Capital income
L_{WRoW} L_{BRoW} L_{FRoW}							Labor income
$TR_{WRoW}F$ $TR_{BRoW}F$ $TR_{FRoW}F$							Firms income
$TR_{WRoW}H$ $TR_{BRoW}H$ $TR_{FRoW}H$							Households income
$TR_{WRoW}G$ $TR_{BRoW}G$ $TR_{FRoW}G$ $TR_{RoW}G_{FED}$							Government income
							Taxes on commodities (VAT tax)
							Taxes on commodities (excises)
							Taxes on capital

			Taxes on labor
			Taxes on production
			Taxes on households income
			Corporate taxes
			Tarrifs
			Subsidies on commodities
			Subsidies on production
			F exch outflows
		SC_{WW} SC_{BB} SC_{FF}	Changes in stocks
$SRoW_W$ $SRoW_B$ $SRoW_F$			Savings
Foreign exchange inflows	Changes in stocks	Investment	

Notation:

C	Final households consumption
CG	Final consumption of the government
DEPR	Depreciation
EM	Exports and imports
I	Investments
IO	Intermediate consumption
K	Capital use of the sector
KG	Capital use of the government
K_{RoW}	Capital income received from Rest of the World
KSF	Income from capital received by the firms
KSH	Income from capital received by the households
KS_{RoW}	Income from capital transfered to the Rest of the World
L	Labor use of the sector
LG	Labor use of the government
L_{RoW}	Labor income received from the Rest of the World
LSH	Income from labor received by the households
LS_{RoW}	Income from labor transfered to the Rest of the World
SC	Total changes in stocks
SF	Firms savings
SG	Government savings
SH	Households savings
SRoW	Foreign savings
SV	Stocks variation
TRV	Taxes on commodities (VAT tax)
TRE	Taxes on commodities (excises)
TREG	Taxes on commodities (VAT tax) received by the regional government
TREG	Taxes on commodities (excises) received by the regional government
TRCS	Subsidies on commodities
TRCSG	Subsidies on commodities paid by the government
TRF	Corporate taxes
TRFG	Corporate taxes received by the government
TRFH	Transfers from the firms to the househols
TRF_{RoW}	Transfers of the firms to the Rest of the World
TRGF	Transfers of the government to the firms
TRGH	Transfers of the government to the households
TRG_{RoW}	Transfers of the government to the Rest of the World
TRH	Taxes on the households income
TRHG	Taxes on households income received by the government
TRK	Taxes on capital
TRKG	Taxes on capital received by the government
TRL	Taxes on wages
TRLG	Taxes on labor received by the government
TRM	Tarrifs on imports
TRMG	Tarrifs received by the government
TRP	Taxes on production
TRPG	Taxes on production received by the government
TRPS	Subsidies on production
TRPSG	Subsidies on production paid by the government
$TR_{RoW}F$	Transfers of the Rest of the World to the firms
$TR_{RoW}G$	Transfers of the Rest of the World to the government
$TR_{RoW}H$	Transfers of the Rest of the World to the households
XDD	Domestic production delivered to the domestic market

5.4. Construction of the regional social accounting matrix for Belgium

Abbreviations

FPB:	Federal planning Bureau
NBB:	National Bank of Belgium
CIF:	Cost insurance freight
COICOP:	Classification of Individual consumption by purpose
SHB:	Survey on the households' budget
GFCF:	Gross fixed capital formation
FOB:	Free on board
NIS:	National institute of statistics
NPMIHS:	Non-profit-making institution in the households' service
SAM:	Social accounting matrix
MEL:	Ministry of employment and labor
MINFIN:	Ministry of finance
NACE-Bel:	Statistical standard classification of the economic activities in the European Community – Belgian equivalent
NACE-CLIO:	Statistical standard classification of the economic activities in the European Community – ramification for the drawing up of input-output tables
NACE-REVISION 1:	Statistical standard classification of the economic activities in the European Community (revision 1)
I-O:	Input-output
ESA 95:	European system of accounts, 1995 version
IMSFI:	Indirectly measured services of financial intermediation
VAT:	Value added tax

Codes of accounts of the european system of the accounts (ESA 95)

B.12:	Balance of the current operations with the rest of the world
B.1g:	Gross value added
B.1n:	Net value added
B.2n:	Net operating surplus (deficit)
B.3n:	Net mixed income
C:	Final consumption by households
D.1:	Wages and remunerations
D.21:	Taxes on products
D.211:	VAT
D.212:	Taxes on imports excluding VAT
D.29:	Other taxes on production
D.31:	Subsidies on products
D.39:	Other subsidies on production
G:	Final public consumption
I:	Investments
K.1:	Fixed capital consumption (depreciation)
M:	Imports
P.1:	Production
P.2:	Intermediate consumption
P.52:	Changes in stocks
X:	Exports

5.4.1. Introduction

The objective of this section is to provide an overview of the construction of a multi-regional (Flanders, Wallonia, Brussels) and a multi-sectoral (60 branches of activities) social accounting matrix for Belgium. This regional SAM is a central element of the model database.

Building process

First stage

Building the Belgian national social accounting matrix for 1997 by updating, on the one hand, the 1990 national input-output matrix until 1997 and by identifying, on the other hand, all flows between the economic agents (households, firms, public services and the rest of the world)

Second stage

Regionalizing the national social accounting matrix by using regional data or targets (when data are not available)

Principles followed in the construction of the SAM

The input-output matrix

Disaggregation of the input-output matrix in 60 branches of activities (sectors) of the NACE-Revision 1 classification:

- Branches X Branches matrix ;
- Components of final demand are expressed at departure-factory prices;
- Building, first, of the matrix of total flows and, then, of domestic and imported flows.

The flows between the economic agents

- Distinction among the public services of the Walloon, Flemish, Brussels, Federal, Social Security administrations and the French community;
- Regrouping of the Federal Government and the Social Security in the central government.

Architecture of a social accountancy matrix (SAM)

		Commodities			Activities			Factors		Institutional accounts		
		Agricultural	Industrial	Private services	Agriculture	Industry	Private services	Capital	Labor	Firms	Households	Government
Commodities	Agricultural				IO	IO	IO				C	CG
	Industrial				IO	IO	IO				C	CG
	Private services				IO	IO	IO				C	CG
Activities	Agriculture	XDD										
	Industry		XDD									
	Private services			XDD								
Factors	Capital				K	K	K					KG
	Labor				L	L	L					LG
Institutional sectors	Firms							KSF				TRGF
	Households							KSH	LSH	TRFH		TRGH
	Government											
Other accounts	Taxes on commodities (VAT)	TRV	TRV	TRV								
	Taxes on commodities (excises)	TRE	TRE	TRE								
	Taxes on capital				TRK	TRK	TRK					
	Taxes on labor				TRL	TRL	TRL					
	Taxes on production				TRP	TRP	TRP					
	Tax on househ income										TRH	
	Corporate taxes									TRF		
	Tarrifs	TRM	TRM	TRM								
	Subs on commodities	TRCS	TRCS	TRCS								
	Sub on production				TRPS	TRPS	TRPS					
Rest of the World		M	M	M				KS_{RoW}	LS_{Row}	TRF_{RoW}		TRG_{RoW}
Changes in stocks												
Savings-Investment					DEPR	DEPR	DEPR			SF	SH	SG
Total		Total supply of commodities (domesticaly produced and imported)			Net outlays of the production sectors			Capital outlays	Labor outlays	Firms outlays	Households outlays	Government outlays

Other accounts										**Rest of the World**	**Changes in stocks**	**Savings-Investment**	**Total**
Taxes on commodities(VAT)	Taxes on commodities(excises)	Taxes on capital	Taxes on labor	Taxes on production	Taxes on household income	Corporate taxes	Tarrifs	Subsidies on commodities	Subsidies on production				
											SV	I	Total
											SV	I	demand
											SV	I	
										E			Gross output
										E			delivered to the
										E			domestic market and exported
										K_{RoW}			Capital income
										L_{RoW}			Labor income
										$TR_{RoW}F$			Firms income
										$TR_{RoW}H$			Households income
TRVG	TREG	TRKG	TRLG	TRPG	TRHG	TRFG	TRMG	TRCSG	TRPSG	$TR_{RoW}G$			Government income
													Taxes on commodities (VAT)
													Taxes on commodities (excises)
													Taxes on capital
													Taxes on labor
													Taxes on production
													Taxes on households income
													Corporate taxes
													Tarrifs
													Subsidies on commodities
													Subsidies on production
													Foreign exchange outflows
												SC	Changes in stocks
										SRoW			Savings
Taxes on commodities(VAT)	Taxes on commodities(excises)	Taxes on capital	Taxes on labor	Taxes on production	Taxes on households income	Corporate taxes	Tarrifs	Subsidies on commodities	Subsidies on production	Foreign exchange inflows	Changes in stocks	Investment	

Notations

C	Final households' consumption from domestic production
CGC	Final consumption of the community (French community) from the domestic production
CGCM	Final consumption of the community (French community) from imports
CGF	Final consumption of the central (federal) government from the domestic production
CGFM	Final consumption of the central (federal) government from the imports
CGR	Final consumption of the regional government from the domestic production
CGRM	Final consumption of the regional government from imports
CM	Final consumption of the households from imports
DEPR	Depreciation
EWB	Exports of Wallonie to Brussels
EWFL	Exports of Wallonie to Flandre
EWRoW	Exports of Wallonie to the Rest of the World
IO	Intermetiate consumption of domestic commodities (from Wallonie)
IOM	Intermetiate consumption from imports
IW	Investments by type of commodity for Wallonie
K	Capital use of the sector
KGC	Capital use of the community
KGF	Capital use of the central government
KGR	Capital use of the regional government
KSF	Income from capital received by the firms
KSGC	Income from capital received by the community
KSGR	Income from capital received by the regional government
KSH	Income from capital received by the households
KSWB	Income from capital transferred by Wallonie to Bruxelles
KSWFL	Income from capital transferred by Wallonie to Flandre
KSWGF	Income from capital received by the federal government from Wallonie
KSWRoW	Income from capital transfered by Wallonie to the Rest of the World
KWB	Capital income received by Wallonie from Bruxelles
KWFL	Capital income received by Wallonie from Flandre
KWRoW	Capital income received by Wallonie from Rest of the World
L	Labor use of the sector
LGC	Labor use of the community
LGF	Labor use of the central government
LGR	Labor use of the regional government
LSH	Income from labor received by the households
LSWB	Income from labor transferred by Wallonie to Bruxelles
LSWFL	Income from labor transferred by Wallonie to Flandre
LSWRoW	Income from labor transfered by Wallonie to the Rest of the World
LWB	Labor income received by Wallonie from Bruxelles
LWFL	Labor income received by Wallonie from Flandre
LWRoW	Labor income received by Wallonie from the Rest of the World
MWB	Commodities imported by Wallonie from Brussels
MWFL	Commodities imported by Wallonie from Flandre
MWRoW	Commodities imported by Wallonie from the Rest of the World
SBW	Funds from Bruxelles available for investment in Wallonie
SFLW	Funds from Flandre available for investment in Wallonie
SFW	Wallonian firms savings
SGCW	French community savings in Wallonie
SGRW	Wallonian government savings
SHW	Wallonian households savings
SRoWW	Surplus/deficit of the balance or payments of wallonie
SubGF	Subsidies paid by the federal government

Architecture of an input-output matrix:

The 60 branches of activities at the Nace-rev.1 nomenclature		**Total of intermediate sales (at purchasing prices) [1]**	Final consumption by households and NPMIHS (departure-factory prices)	Public final consumption	Gross fixed capital formation (departure-factory prices)	Exports (departure-factory prices)	Total final demand (departure-factory prices) [2]	Imports (departure-factory prices) [3]	***Production at departure-factory prices*** **[1] + [2] – [3]**
Total flows 1 2 … 95 99	Matrix of consumption and intermediate sales (at purchasing prices)								
Intermediate consumption (at purchasing prices) [P.2]									
The employees' remunerations (D1)									
Fixed capital consumption (K1)									
Net operating surplus and mixed incomes (B2n+B3n)									
Other taxes on production (D29)									
(-) Other subsidies on production (D39)									
Gross value added at basic prices (B.1g)									
Production at basic prices (P.2+B.1g)[P1]									
Taxes on products excluding VAT and taxes on imports (D214)									
(-) Subsidies on products (D31)									
Production at departure-factory prices									

We mainly based the building of the social accounting matrix on the diagram of a social accounting matrix worked out by the European System of Accounts (the 1995 European System of Accounts ESA, page 220).

With regard to the plan of the input-output matrix, we were largely inspired by the plan worked out by the Federal Planning Bureau within the framework of the building of their national input-output matrices.

5.4.2. Building of the 1997 Belgian national social accounting matrix

Starting point: obtaining the production data at basic prices according to the NACE-Rev.1 nomenclature

In November 2000, the National Accounts Institute of the National Bank of Belgium, via the financial and economic Statistics Service, provided us, on a confidential basis, with the following data:

- the value of production at basic prices (P1),
- the value of intermediate consumption at purchasing prices (P2),
- the value added at basic prices (B1g = P1 – P2),
- the wages and remunerations (D1),

for the years 1995 to 1999, for the 60 sectors (branches of activities) of the NACE-Revision 1 nomenclature.

At this stage, two problems arose:

- the need of splitting " indirectly measured services of financial intermediation (IMSFI)" into the branches of activities supposed to receive these values
- the need to determine the values for the components of value added other than employees' remunerations

These two problems were resolved in the following way:

1°) We estimated the 60 sectors of production at basic prices and split the indirectly measured services of financial intermediation (IMSFI)

Indeed, the confidential statistics for 60 sectors of the NACE-Bel provided by the NBB, were different – for some values - of published statistics. This involves exactly the total of intermediate consumption (P.2) and the total of value added (B.1). We then subtracted the IMSFI from value added and added it to the intermediate consumption. Finally, the IMSFI was split among financial sectors.

The splitting of the "indirectly measured services of financial intermediation (IMSFI)" was done according to the branches of activities which were supposed to offer these IMSFI, namely all financial branches i.e. 65 [*financial intermediation*], 67 [Activities auxiliary to financial intermediation].

The target used for splitting the IMSFI is the gross value added (B1g) of branches of activities 65, 67.

This splitting is reflected within these sectors by an increase in their intermediate consumption and, in compensation (since it is assumed that the value of the production of each branch is measured correctly), by a reduction in value added (in fact, it is the net operating surplus which is reduced).

2°) Splitting of components of value added other than the employees' remunerations in the 60 branches of activities

The goal is to estimate the components (here below) of added value at basic prices within the 60 branches of activities:

- the consumption of fixed capital (K1),
- the net operating surplus (B2.n) and mixed incomes (B3.n),
- other taxes on production (D29),
- other subsidies on production (D39).

To this end, we used the information on K1, B2.n-B3.n, D29 and D39 for the 29 branches of activities in order to desagregate into the necessary 60 branches of activities (source: National Accounts Institute, NBB, "National Accounts 1999 – Part 2. Detailed accounts and tables ", Brussels, 2000, pp.55-58).

The target used to split the information (data) available for the 29 branches into the 60 branches of NACE-rev.1 is based on *value added* minus *employees' remunerations* (B1g – D1).

Estimate of production at the departure-factory prices for 1997

By definition:

The value of production at the departure-factory prices (dfp) is obtained by adding to the value of production at basic prices (bp) taxes on products excluding VAT and taxes on imports (D214) and by subtracting subsidies on products (D31).

In other words: $Prod_{dfp} = Prod_{bp} + D.214 - D.31$

Estimate of D214 (taxes on products excluding VAT and taxes on imports) for the 60 sectors of the Nace-rev.1 classification

On the basis of data published by the National Accounts Institute of the NBB concerning the different types of taxes of D214 and the amounts received either by the Public service, or by the rest of the world, we associated each one of these taxes with one or more branches of activities of the NACE-rev.1. It is in this way that a value for the D214 heading could be associated to each of the 60 branches of activities of the input-output matrix.

Estimate of D31 (subsidies on products) for the 60 branches of activities of the Nace-rev.1

Table 1, column 2, presents the total subsidies received by firms (D3) in 1990 for the 60 sectors of the NACE-CLIO nomenclature. This information was provided us by the Federal Planning Bureau that used it within the framework of the establishment of the 1990 input-output matrix.

Table 1, column 4, presents the same subsidies split by branches of activities of the NACE-rev.1 classification (link between NACE-CLIO and NACE-rev.1: see conversion table; target used for converting the subsidies of the NACE-CLIO branches to the corresponding branches of the NACE-rev.1 is the value of the 1997 production at basic prices).

The last column of table 1 indicates the relative shares of subsidies allocated in 1990 to the different branches of activities (available in 1997).

The relative shares obtained were then used to split the total subsidies paid in 1997, i.e. 156 billion BEF (source: National Accounts Institute, NBB, "National Accounts 1999", Brussels, 2000), in the 60 branches of activities of the NACE-rev.1. We thus obtain a first estimate of the subsidies (D3) in 1997 (table 2 – column 3).

In order to obtain a first estimate of *subsidies on products (D31)* in 1997 (table 2 – column 5), it is necessary to subtract from the total subsidies (D3) *other subsidies on production (D39)* paid in 1997 (table 2 – column 4).

The first estimate of *subsidies on products (D31)* is then adjusted:

- by equating to zero negative values appearing for certain branches of activities,
- by respecting the D31 total obtained by the first estimate,
- by respecting shares of D31 obtained from the first estimate in branches of activities where D31 presents a positive value.

Table 1 : Presentation of the 1990 subsidies according to the Nace-rev.1 classification

CODE NACE/CLIO	The 1990 subsidies (source FPB)	CODES NACE-BEL	The 1990 subsidies	Target used : the 1997 production at basic prices	Subsidies shares of sectors available until 1997
1	13034.0000	**1**	12576	295253	0.0632
3.1	1378.0000	**2**	245	5760	0.0012
3.3	0.0000	**5**	212	4987	0.0011
5	0.0000	**10**	1378	0	0.0000
7.1	0.0000	**11**	100	0	0.0000
7.3	1998.0000	**12**	0	0	0.0000
7.5	100.0000	**13**	0	0	0.0000
9.5	900.0000	**14**	10	31557	0.0001
9.7	434.0000	**15**	16223	925493	0.0816
9.8	0.0000	**16**	70	27831	0.0004
13.5	433.0000	**17**	888	267917	0.0045
13.6	173.0000	**18**	172	85160	0.0009
13.7	1097.0000	**19**	7	13266	0.0000
15.1	46.0000	**20**	210	84374	0.0011
15.3	179.0000	**21**	35	115346	0.0002
15.5	170.0000	**22**	736	226004	0.0037
15.7	84.0000	**23**	1998	212066	0.0100
15.9	178.0000	**24**	1246	907576	0.0063
17.1	1203.0000	**25**	951	209521	0.0048
17.3	43.0000	**26**	647	234651	0.0033
19	903.0000	**27**	1703	505474	0.0086
21	649.0000	**28**	903	332593	0.0045
23	35.0000	**29**	649	295615	0.0033
25	1346.0000	**30**	35	6639	0.0002
27	1300.0000	**31**	657	165065	0.0033
29	195.0000	**32**	530	133168	0.0027
31	994.0000	**33**	158	39788	0.0008
33	2546.0000	**34**	1300	664357	0.0065
35	11236.0000	**35**	195	44241	0.0010
37	1447.0000	**36**	352	129928	0.0018
39	70.0000	**37**	142	39227	0.0007
41.1	172.0000	**40**	434	362144	0.0022
41.3	888.0000	**41**	900	33073	0.0045
43	7.0000	**45**	715	1223269	0.0036
45	534.0000	**50**	3988	454371	0.0201
47.1	35.0000	**51**	10747	1285591	0.0540
47.3	736.0000	**52**	6786	811728	0.0341
49.1	35.0000	**55**	342	317817	0.0017
49.3	916.0000	**60**	78169	432655	0.3931
51	28.0000	**61**	894	98748	0.0045
53	715.0000	**62**	0	133751	0.0000
55.1	189.0000	**63**	0	479654	0.0000
55.3	142.0000	**64**	11976	294142	0.0602
57	21332.0000	**65**	7070	556126	0.0356
59	342.0000	**66**	0	231542	0.0000
61.1	77972.0000	**67**	1654	130106	0.0083
61.3	197.0000	**70**	25831	1062884	0.1299
61.7	225.0000	**71**	262	100080	0.0013
63.1	669.0000	**72**	369	140892	0.0019
63.3	0.0000	**73**	96	36783	0.0005
65	0.0000	**74**	3699	1413856	0.0186
67	11976.0000	**75**	0	842894	0.0000
69.1	8724.0000	**80**	0	600840	0.0000
69.3	0.0000	**85**	920	789956	0.0046
71	5573.0000	**90**	131	50150	0.0007
73	25831.0000	**91**	268	102617	0.0014
77	920.0000	**92**	457	174730	0.0023
81	0.0000	**93**	176	67113	0.0009
85	0.0000	**95**	115	43951	0.0006
TOTAL	200329.0000	**99**	0	0	0.0000
		Total	200329	18274320	1.0000

Table2 : Presentation of the 1997 subsidies according to the Nace-rev.1 classification

CODE NACE-BEL	Sectoral shares of existing sectors until 1997	The 1997 subsidies (D3) en 1997 - 1st estimate	The 1997 other subsidies on production (D39)-(source : PRODPRIXBASE.xls file)	The 1997 subsidies on products (D31) - 1st estimate	The 1997 subsidies on products (D31) - adjusted estimate	The total 1997 subsidies - adjusted estimate
1	0.0632	9866	2106	7760	6686	8792
2	0.0012	192	87	106	91	178
5	0.0011	167	61	106	91	152
10	0.0000	0	0	0	0	0
11	0.0000	0	0	0	0	0
12	0.0000	0	0	0	0	0
13	0.0000	0	0	0	0	0
14	0.0001	8	18	-10	0	18
15	0.0816	12727	1679	11048	9519	11198
16	0.0004	55	77	-22	0	77
17	0.0045	697	513	183	158	671
18	0.0009	135	92	43	37	129
19	0.0000	5	20	-15	0	20
20	0.0011	165	1183	-1018	0	1183
21	0.0002	27	415	-388	0	415
22	0.0037	577	772	-195	0	772
23	0.0100	1567	0	1567	1351	1351
24	0.0063	977	353	624	538	891
25	0.0048	746	269	477	411	680
26	0.0033	508	165	343	295	460
27	0.0086	1336	537	799	688	1225
28	0.0045	708	500	209	180	680
29	0.0033	509	166	343	295	462
30	0.0002	27	19	9	8	26
31	0.0033	516	813	-298	0	813
32	0.0027	416	830	-414	0	830
33	0.0008	124	191	-66	0	191
34	0.0065	1020	228	792	682	910
35	0.0010	153	34	119	102	137
36	0.0018	276	236	40	34	270
37	0.0007	111	60	52	44	104
40	0.0022	340	237	103	89	326
41	0.0045	706	14	692	596	610
45	0.0036	561	993	-432	0	993
50	0.0201	3128	251	2877	2479	2730
51	0.0540	8431	1047	7385	6363	7410
52	0.0341	5324	669	4655	4011	4679
55	0.0017	268	180	88	76	256
60	0.3931	61324	1245	60079	51765	53010
61	0.0045	701	100	601	518	618
62	0.0000	0	73	-73	0	73
63	0.0000	0	1054	-1054	0	1054
64	0.0602	9395	2161	7235	6233	8394
65	0.0356	5546	1819	3728	3212	5031
66	0.0000	0	433	-433	0	433
67	0.0083	1298	343	954	822	1166
70	0.1299	20265	14226	6039	5203	19429
71	0.0013	205	753	-548	0	753
72	0.0019	289	257	32	28	285
73	0.0005	75	19	56	49	68
74	0.0186	2902	6730	-3829	0	6730
75	0.0000	0	0	0	0	0
80	0.0000	0	0	0	0	0
85	0.0046	722	6844	-6122	0	6844
90	0.0007	103	316	-213	0	316
91	0.0014	211	52	159	137	189
92	0.0023	359	1297	-939	0	1297
93	0.0009	138	591	-453	0	591
95	0.0006	90	0	90	78	78
99	0.0000	0	0	0	0	0
Total	**1.0000**	**156000**	**53129**	**102871**	**102871**	**156000**

Building of columns of the final demand

Private consumption

We obtained data from two institutions:

- NBB: aggregated data
- FPB: Coicop, data of the functions of the households' consumption.

Stages of splitting private final consumption according to the NACE-rev.1 nomenclature:

- Disaggregation of data from Coicop and splitting in NACE-rev.1
- Passage to the departure-factory price, which is equal to purchasing prices – VAT – trade and transport margins.
- The transport and trade margins are then reallocated respectively in the transport and trade services according to the production of sectors.
- The trade and transport margins come from the FPB and the VAT rates from the Ministry of Finance.
- Passage from splitting of consumer expenditure for 60 the sectors according to production to the splitting according to distribution. This passage is very important since the sector which produces is not necessarily the one that supplies the good.
- The transfer amounts from the sectors 1, 2, 5, 15 and 17 to the sectors 55 and 85 come from the FPB.
- Private final consumption = final consumption by households + final consumption by the NPMIHS

The gross fixed capital formation

Table 1 comes from the Federal Planning Bureau. The results from this table, namely the gross fixed capital formation at producer prices, after reassignment of the margins and excluding VAT, represent the column of the final demand "gross fixed capital formation" of the 1990 input-output matrix.

Table 1 : Branches which supply the GFCF in the 1990 national input-output matrix, in millions of BEF (source: Federal Planning Bureau)

		GFCF	GFCF			GFCF		
Codes		**at purchasing prices including VAT**	**at purchasing prices excluding VAT**	**Non deductible VAT**	**Used non deductible VAT rates**	**At producer prices after reallocation of margins, excluding VAT**	**margins, VAT excluded**	**Used margin rates**
CLIO 01.0	1.Agriculture, forestry and fishing	2397	2397	0	0.00%	2397	0	-
CLIO 19.0	Metal products	70446	70132	314	0.45%	68763	1369	2%
CLIO 21.0	Machines for agriculture and industry	250050	250050	0	0.00%	242291	7759	3%
CLIO 23.0	Manufacture of office machinery	56495	56184	311	0.55%	52372	3812	7%
CLIO 25.0	Electrical machinery and apparatus	104558	103927	631	0.61%	96185	7742	7%
CLIO 27.0	Motor vehicles and their engines	111800	110772	1028	0.93%	99141	11631	10%
CLIO 29.0	Other passenger transport	23415	23415	0	0.00%	23227	188	1%
CLIO 45.0	Wood and wood products	7997	7683	314	4.09%	6925	758	10%
CLIO 53.0	Buildings and civil engineering works	639237	587106	52131	8.88%	587106	0	-
CLIO 55.3	Recycling and other repairs	-22308	-22308	0	0.00%	-28864	6556	29%
CLIO 57.0	Sale services	0	0	0	0.00%	31513	-31513	-
CLIO 61.1	Transport via railways	0	0	0	0.00%	73	-73	-
CLIO 61.3	Transport by road and others n.c.e	0	0	0	0.00%	4370	-4370	-
CLIO 61.7	Services of national navigation	0	0	0	0.00%	11	-11	-
CLIO 65.0	Supporting and auxiliary transport activities	0	0	0	0.00%	3848	-3848	-
CLIO 71.0	Services provided to firms and households	59712	59712	0	0.00%	59712	0	-
	Total	**1303799**	**1249070**	**54729**	**4.38%**	**1249070**	**0**	**-**

Table 2 comes from the national accounts. The National Accounts Institute publishes branches which supply the GFCF in the form presented in this table. Table 2 provides the values for 1997.

Table 2: Branches which supply the GFCF in 1997

	GFCF
1.Products of agriculture, forestry and fishing	7827
2.Equipement	944359
a.Metal products and machines	777471
b.Transport	166888
3.Construction	729357
a.Lodging	382325
b.Construction of non residential buildings and civil engineering works	347032
4.Other products	135507
Total (price including non deductible VAT and margins)	1817050

Source: National Bank of Belgium

Table 3 makes the connection between branches that supply the GFCF according to the National Accounts to the branches of activities of the NACE-rev.1. The target used for converting these sectors from the National Accounts to the NACE-rev.1 classification is the value of domestic sales for corresponding sectors of the NACE-rev.1.

Table 3 : Branches which supply the GFCF in 1997 according to the NACE-rev.1 classification

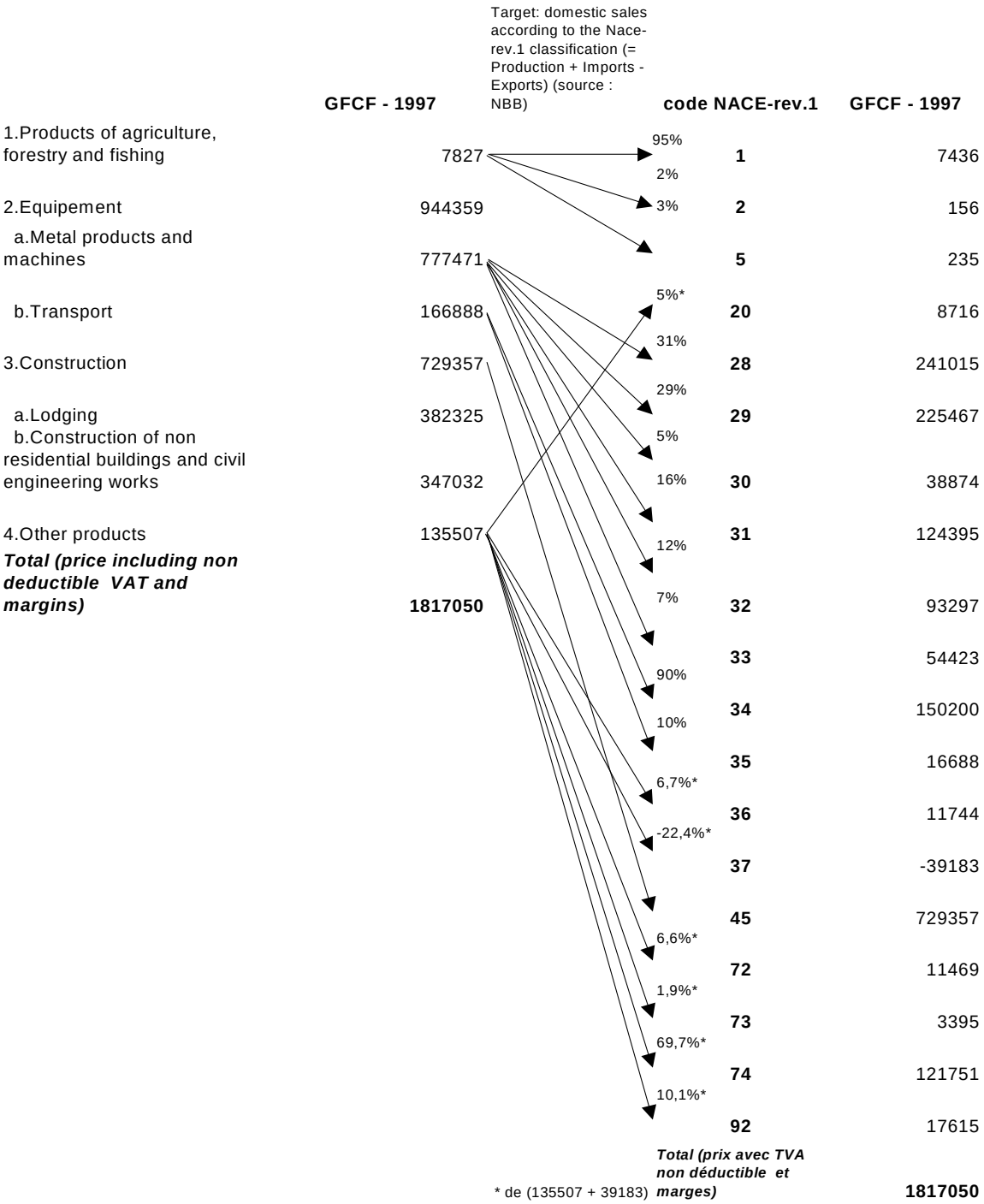

Table 4 has the same structure as table 1 except that here branches of activities are presented in the NACE-rev.1 classification.

On the basis of the GFCF at purchasing prices, VAT included, resulting from table 3, we now allocate the same rates of non deductible VAT and the same margin rates estimated from table 1 in order to obtain the GFCF at producer prices, after reallocation of trade and transport margins and excluding VAT, which will be used in the 1997 national input-output matrix.

Table 4 : Estimate of banches which supply the GFCF in the 1997 national input-output matrix, in millions of BEF (NACE-rev.1 classification)

code NACE-rev.1		**FBCF aux prix acheteurs, TVA incluse**	**FBCF aux prix acheteurs, TVA exclue**	TVA non déductible	Taux de TVA non déductible appliqués	**FBCF aux prix producteurs, après réaffectation des marges, TVA exclue**	Marges, TVA exclue (valeurs positives) réaffections des marges (valeurs négatives)	Taux de marges (valeurs positives) clés de réaffectation
1	Agriculture, hunting and related service activities	7436	7436	0	0.00%	**7436**	0	0.00%
2	Forestry, logging and related service activities	156	156	0	0.00%	**156**	0	0.00%
5	Fishing, operation of fish hatcheries and fish farms	235	235	0	0.00%	**235**	0	0.00%
20	Manufacture of wood and wood products	8716	8374	342	4.09%	**7536**	837	10.00%
28	Manufacture of fabricated metal products	241015	239935	1080	0.45%	**235137**	4799	2.00%
29	Manufacture of machinery and equipment	225467	225467	0	0.00%	**218703**	6764	3.00%
30	Manufacture of office machinery and computers	38874	38661	213	0.55%	**35955**	2706	7.00%
31	Manufacture of electrical machinery and apparatus	124395	123641	754	0.61%	**114986**	8655	7.00%
32	Manufacture of radio, television and communication equipment	93297	92731	566	0.61%	**86240**	6491	7.00%
33	Manufacture of radio, television and communication equipment and apparatus	54423	54093	330	0.61%	**50307**	3787	7.00%
34	Manufacture of motor vehicles, trailers and semi-trailers	150200	148816	1384	0.93%	**133934**	14882	10.00%
35	Manufacture of other transport equipment	16688	16688	0	0.00%	**16521**	167	1.00%
36	Manufacture of furniture; manufacturing	11744	11283	461	4.09%	**10154**	1128	10.00%
37	Recycling	-39183	-39183	0	0.00%	**-50546**	11363	29.00%
45	Construction	729357	669872	59485	8.88%	**669872**	0	0.00%
50	Sale, maintenance and repair of motor vehicles and motorcycles					**7569**	-7569	12.29%
51	Wholesale trade and commission trade					**21416**	-21416	34.78%
52	personal and household goods					**13522**	-13522	21.96%
60	Land transport; transport via pipelines					**7207**	-7207	11.70%
61	Water transport					**1645**	-1645	2.67%
62	Air transport					**2228**	-2228	3.62%
63	Supporting and auxiliary transport activities					**7990**	-7990	12.98%
72	Computer and related activities	11469	11469	0	0.00%	**11469**	0	0.00%
73	Research and development	3395	3395	0	0.00%	**3395**	0	0.00%
74	Other business activities	121751	121751	0	0.00%	**121751**	0	0.00%
92	Recreational, cultural and sporting activities	17615	17615	0	0.00%	**17615**	0	0.00%
	Total	**1817050**	**1752435**	**64615**	**3.69%**	**1752435**	**0**	

The final consumption expenditure by governments

The public final consumption in 1997 amounts to *BEF 1,857,166 million (source: National Accounts Institute, NBB)*. In the 1997 input-output matrix, this final demand has to be assigned to three branches of activities:

75: Public service,

80: Education and

85: Health and social work.

The production value of the *Public service* sector [source: NBB] amounts to BEF 845753 million; in the I-O matrix, this value is assigned entirely to public final consumption.

The amount of the sector *Education* assigned to total final public consumption amounts to BEF 577797 million and comes from the balance of the difference between the production of this sector (BEF 600840 million [source: NBB]) and the amount assigned to household consumption (BEF 23043 million [personal estimate coming from the column on "private consumption" of the 1997 matrix I-O]).

The balance between the public final consumption (BEF 1.857.166 million), on the one hand, and the estimated production values of sectors *Public service* and *Education* for public final consumption (BEF 1,423,550 million)), on the other hand, determines the final demand in *Health and social work* from the public sector, its amounts to BEF 433616 million.

Foreign trade

Exports (before adjustment)

We obtained data from the National Bank of Belgium. Exports of:

- Goods come from the foreign trade statistics of the NBB.
- Services come from the balance of payments of the National Accounts, NBB.

The total of exports differ from the total published by the National Accounts due to the Community definition of goods (national conformity rules and re-exportations).

Stages of splitting exports according to the NACE-rev.1 classification:

DISAGGREGATION and splitting of exports of services from balance of payments (BOP) according to the NACE-rev.1.

Splitting was done according to the relative shares of the sectors in the 1990 input-output matrix published by the FPB.

Passage to the departure-factory price, that is equal to fob prices – trade and transport margins.

The trade and transport margins are then reallocated respectively to sectors that deal with trade and transport services according to production of these sectors.

Imports

We obtained data from the National Bank of Belgium (the same sources as those for exports).

Stages of splitting imports according to the NACE-rev.1 nomenclature:

We followed the same stages as exports except for the definition of the departure-factory prices (or customs departure prices).

Departure-factory prices = c.i.f prices + excise and customs duties

Net exports

To respect the value of net exports provided by the National Accounts, we carried out an adjustment of the net exports value estimated in the building process of the 1997 national I-O matrix.

The adjustment covered exports of services since the reallocation of trade and transport margins estimated from exports of goods would tend to inflate the final values of exports of services due to the Community definition of exports of goods.

Computation of the intermediate sales

Computation of intermediate sales (changes in stocks included) at purchasing prices is obtained by the balance of:

Intermediate sales (purchasing prices) + changes in stocks (departure-factory prices)
=
Production (departure-factory prices)
+
Imports (departure-customs prices)
-
The final consumption by households and NPMIHS (departure-factory prices)
-
Public final consumption
-
Gross fixed capital formation (departure-factory prices)
-
Exports (departure-factory prices)

The difference between, on the one hand, the total intermediate consumption and, on the other hand, the total of the intermediate sales and changes in stocks gives the total changes in stocks since the total of the intermediate sales has to be equal to the total of the intermediate consumptions.

Changes in stocks are then split between branches of activities providing goods according to their production. They are also used to balance the I-O matrix if necessary.

Estimate of the matrix of the intermediate total flows

Converting rows of the intermediate total flows of the 1990 input-output matrix from the NACE-Clio to the NACE-Rev.1

This stage consists in converting rows of the 1990 matrix of intermediate sales and consumptions from the NACE-Clio to the NACE-Revision 1.

To obtain this result, we established a link between the two nomenclatures (see the conversion table NACE-Clio – Nace-rev.1) and used the 1997 estimated intermediate sales in order to convert rows from the NACE-Clio to the NACE-rev.1.

Converting columns of the intermediate total flows of the 1990 input-output matrix from the NACE-Clio to the NACE-Rev.1

This stage consists in converting columns of the 1990 matrix of intermediate consumptions from the NACE-Clio to the NACE-Revision 1.

To obtain this result, in addition to the link established between the two classifications, we used the 1997 estimated intermediate consumptions in order to convert columns from the Nace-Clio to the Nace-rev.1.

Computation of the matrix of intermediate total flows 1997

From the 1990 matrix of technical coefficients (worked out by the Federal Planning Bureau and which we converted into the NACE-rev.1 classification in the previous stages, 1 and 2) and the 1997 totals of rows and columns (respectively the 1997 intermediate sales and intermediate consumptions), we estimated, using the *RAS* method, the 1997 matrix of technical coefficients by respecting the marginal conditions (the total of the intermediate sales has to be equal to the total of the intermediate consumptions).

From this new technical coefficient matrix, we reconstituted the 1997 matrix of intermediate total flows.

Flows between the economic agents

In addition to the intermediate consumptions, the final demand and the value added of the 60 branches of activities, the SAM also includes flows between households, firms, public institutions and the rest of the world.

The final presentation of the SAM we built modifies slightly the presentation of the European System by incorporating some elements proposed by Marcelle Thomas and Romeo L. Bautista in their article "*A 1991 Social Accounting Matrix for Zimbabwe* ".

The modification covers primarily the account in capital, of which resources come from savings of all economic agents, and the expenditures by investments. The balance between the resources and the expenditures is the balance of the current operations with the rest of the world (B.12).

In the building process of flows carried out by economic agents, we encountered some small problems.

Indeed, since our figures are mainly taken from the statistics published by the National Bank of Belgium (NBB) and these being often liable to modifications (or updates), we therefore had to adjust certain stations to reach the balance of the economy as a whole.

In other words, the existing period difference in the building of the different components of the SAM and the adjustments performed on certain statistics have the effect that the balance, i.e. total expenditure equal total income of certain stations, can only be reached after some adjustment.

The performed adjustments covered the stations below:

Current transaction with the rest of the world (B.12): the adjustment of this station is solely connected with the accounting concept.

Indeed, the updates of the total investments by the National Bank of Belgium while the 1997 estimated investments for the 60 sectors of the input-output matrix referred to the old statistics, led us to adjust the value of current transactions with the rest of the world.

Savings of economic agents: the savings are also used to solve the unbalance of the capital account of economic agents.

But adjustment made should not exceed 5 % of the value.

Changes in stocks (P.52): was used as adjustment and correction of statistical errors and omissions.

5.4.3. Regionalization of the national social accounting matrix

Below are the steps followed in regionalising the national SAM:

- Regionalization of the national input-output matrix
- Decomposition of the matrix of total flows in domestic and imported flows
- Converting the 1990 matrices of domestic and imported flows of NACE-Clio, worked out by the federal planning bureau, to the NACE-Rev.1

Estimate of the 1997 matrices of domestic and imported flows

Regionalization of value added at factors prices and production at the departure-factory prices for the 60 sectors of NACE-Revision 1

Four sources of data were used for the regionalization of the value added at factors prices and production at departure-factory prices for the 60 sectors of Nace-rev.1:

- statistics of production PRODCOM (NIS)
- statistics of national employment (MEL)
- statistics of turnover from to the VAT report (NIS)

- statistics of value added (NBB)

The value added (V.A.)

To regionalize the value added, since we had, on the one hand, only the regional statistics of the 29 branches gathering the 60 sectors of activities of the NACE-revision 1 and, on the other hand, the statistics of V.A. for the 60 sectors, we firstly transformed the V.A. block of the 1990 input-output matrix and obtained initial technical coefficients for applying the RAS for each branch.

The components of the value added (at departure-factory price):

- consumption of fixed capital (K.1.),
- net operating surplus and mixed incomes (B.2n+B.3n),
- taxes on products excluding VAT and taxes on imports (D214),
- other taxes on production (D29),
- subsidies on products (D31) and
- other subsidies on production (D39)

were regionalized according to the regional productions at the departure-factory prices.

The production

The regionalization of production is based, first of all, on statistics of production PRODCOM. When information was not available, we referred to the regional shares of national employment, the turnover of firms and the value added. However, a preliminary comparison of the divergences - in term of the regional shares – due to the change of the (three) targets, was necessary for the final choice of the target to be used. Also let us stress the fact that it is the estimate of regional productions was our first regionalization stage.

The intermediate consumption

By definition, the intermediate consumption of a sector at the regional level is the balance between, on the one hand, the regional production at the departure-factory prices and, on the other hand, the regional value added at factors cost plus the regional taxes and subsidies.

If, for a given sector, it is supposed that the composition of intermediate consumption, which is necessary for the production of a unit of product is identical in three regions, it is then possible to split columns of intermediate consumptions from the national matrix previously estimated in the three regions. This suffices to use as the target, the intermediate consumption of each branch of activity estimated at the regional level.

Regionalization of the final demand

The final consumption by households

The regionalization of the column of the final consumption by households of the 97/98 input-output matrix was carried out from the survey on the households' budgets (SHB).

From this survey, we estimated the regional shares of consumption expenditures for each sector.

We thereafter multiplied the regional expenditure of each sector by the total number of households for each region since the expenditure of the SHB is expressed in average expenditure per household. Values obtained represent the total regional expenditures for each sector.

The same method was followed for the final consumption from the non-profit-making institutions to the households' service (NPMIHS).

The final consumption expenditure by governments

The regionalization of public final consumption was carried out in the following way:

For all public sectors i.e. sectors 75 *"Public service"* , 80 *"Education"* and 85 "*Health and social work* ", we used as the target the regional expenditures of governments from the Ministry of Finance.

The gross fixed capital formation

The regionalisation of the gross fixed capital formation was carried out in the following way.

For branches that supply the GFCF goods, we used as the target the total regional investments shares from the 1997 VAT report published by the National Institute of Statistics.

The exports

The regionalization of exports was made in two stages:

1°) regionalization of exports of goods

- converting exports of goods from the harmonized system (with 22 groups) to the NACE-rev. 1 (sectors 1 to 41)
- adjustment of the totals obtained in order to converge to the national totals estimated beforehand
- regional splitting according to the shares provided by the harmonized system

2°) regionalization of exports of services

- target used for regionalization of exports of services is the regional productions at departure-factory prices

- adjustments were applied on the amounts of exports exceeding the regional production

The Imports

After desagregration of the matrix of total flows into two matrices, the domestic flows matrix and the imported flows matrix, we distinguished, on the one hand, the domestic sales and, on the other hand, the imports.

To resume the regionalization process, the regionalization applies only on the domestic sales since the imports, that represent sales by the foreign countries (or the rest of the world) to Belgium, cannot be regionalized since they are not national values.

The row of the total sales (i.e. national sales in the matrix of total flows) from the sector i to the sector j is divided into four lines:

- Walloon sales from the sector i to the sector j
- Flemish sales from the sector i to the sector j
- Brussels' sales from the sector i to the sector j
- Rest of the world' sales from the sector i to the sector j

The changes in stocks

The changes in stocks were regionalized according to the regional production at the departure-factory prices. As mentioned before, changes in stocks were also used for adjustment purposes.

Regionalization of sales (or regionalization of rows of the national input-output matrix)

To regionalize the domestic sales, we mainly based ourselves on the 1997 estimated domestic and imported input-output matrices obtained beforehand through the RAS method.

Rows of the domestic input-output matrix were regionalized according to the regional sales out of the rest of the world (i.e. total regional sales minus exports to the rest of the world minus changes in stocks). We subtracted exports since we adjusted the regional exports in order to respect values from the national accounts and, changes in stocks due to the adjustment role played by these values.

We may also directly regionalize the national social accounting matrix from the total flows matrix (imported lows and domestic flows together).

In this case, each national row will be split in three rows: Wallonia, Flanders and Brussels.

We adopted this second presentation (regionalization type) for simplifying the modeling part. However, the structure of the model remains exactly the same.

Regionalization of flows between agents

At the time of the regionalization of flows between the economic agents, we distinguished among the public institutions, in addition to the three regions (Wallonia, Flanders and Brussels), the French Community, the Federal Government and the Social Security Administration.

As the Social Security Administration is a centralized institution, we attached it to the Federal Government in order to constitute only one institution called the "Central Institution" (or Central Government).

Unavailability or scarcity of regional data, led us to use other regional data that are available and more related to values to be split.

Hereafter are the regional data as well as sources used for the regionalization of national flows taking place between the economic agents:

- Regional turnover of firms (NIS)
- Investments by region (NIS)
- Population by region (NBB)
- Number of households by region (NIS)
- Employment by region (MEL)
- Remunerations by region (NBB)
- The household income tax (HIT) by region (MINFIN)
- The value-added tax (VAT) by region (MINFIN)
- Debt by region (MINFIN)
- Production by region (personal estimates)

Indeed, the social transfers were regionalized according to the regional employment, subsidies on capital according to the regional investments, subsidies and taxes on production according to the regional productions at the departure-factory prices, subsidies and taxes on products according to the VAT, remunerations of employees according to the regional remunerations, the household income tax according to the regional wages and the property income according to the regional turnover.

NACE REVISION 1

Code	Description
01	Agriculture, hunting and related service activities
02	Forestry, logging and related service activities
05	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
10	Mining of coal and lignite; extraction of peat
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12	Mining of uranium and thorium ores
13	Mining of metal ores
14	Other mining and quarrying
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture fibreboard and other panels and boards
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.
37	Recycling
40	Electricity, gas, steam and hot water supply
41	Collection, purification and distribution of water
45	Construction
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55	Hotels and restaurants
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation
70	Real estate activities

71 Renting of machinery and equipment without operator and of personal and household goods
72 Computer and related activities
73 Research and development
74 Other business activities
75 Public administration and defence; compulsory social security
80 Education
85 Health and social work
90 Sewage and refuse disposal, sanitation and similar activities
91 Activities of membership organizations n.e.c.
92 Recreational, cultural and sporting activities
93 Other service activities
95 Private households with employed persons
99 Extra-territorial organizations and bodies

NACE-CLIO classification:

NACE-CLIO codes	Heading
CLIO 01.0	Agricultural, forestry and fishery products
CLIO 03.1	Coal and coal briquettes
CLIO 03.3	Lignite (brown coal) and lignite briquettes
CLIO 05.0	Products of coking
CLIO 07.1	Crude petroleum
CLIO 07.3	Refined petroleum products
CLIO 07.5	Natural gas
CLIO 09.5	Water
CLIO 09.7	Electric power, steam and hot water
CLIO 09.8	Manufactured gas
CLIO 11.0	Nuclear fuels
CLIO 13.5	Ferrous ores and metals (ECSC products)
CLIO 13.6	Ferrous metals (non ECSC products)
CLIO 13.7	Non-ferrous ores and metals
CLIO 15.1	Cement, lime, plaster
CLIO 15.3	Glass and products of glass
CLIO 15.5	Ponery products and Ceramic products
CLIO 15.7	Other non metallic products
CLIO 15.9	Building and construction materials
CLIO 17.1	Chemical products
CLIO 17.3	Artificial and synthetic fibres
CLIO 19.0	Metal products
CLIO 21.0	Agricultural and industrial machinery
CLIO 23.0	Office machines and data processing machines
CLIO 25.0	Electrical goods
CLIO 27.0	Motor vehicles
CLIO 29.0	Other transport equipment
CLIO 31.0	Meats, meat preparations and preserves
CLIO 33.0	Milk and dairy products
CLIO 35.0	Other food products
CLIO 37.0	Beverages
CLIO 39.0	Tobacco products
CLIO 41.1	Products of the hosiery trade and ready-made clothes
CLIO 41.3	Other textile products
CLIO 43.0	Leathers, leather and skin goods, footwear
CLIO 45.0	Timber, wooden products and furniture
CLIO 47.1	Wood pulp, paper, board
CLIO 47.3	Paper and printing products
CLIO 49.1	Rubber products
CLIO 49.3	Plastic products
CLIO 51.0	Other manufacturing products
CLIO 53.0	Building and construction
CLIO 55.1	Repair of motor vehicles and bicycles
CLIO 55.3	Recycling and other repairs services
CLIO 57.0	Wholesale and retail trade
CLIO 59.0	Lodging and catering services
CLIO 61.1	Railway transport services and tramways
CLIO 61.3	Road transport and other land-born transport services
CLIO 61.7	Inland waterways services
CLIO 63.1	Maritime transport services
CLIO 63.3	Air transport services
CLIO 65.0	Auxiliary transport services
CLIO 67.0	Communication services
CLIO 69.1	Services of credit institutions
CLIO 69.3	Services of insurance institutions
CLIO 71.0	Business services provided to enterprises and households
CLIO 73.0	Services of renting of immovable goods
CLIO 77.0	Health services
CLIO 81.0	Public administrations
CLIO 85.0	Education services and R&D

Conversion table FROM NACE-BEL to NACE-CLIO

NACE-BEL CODES	NACE/CLIO CODE
1	1
2	1
5	1
10	3.1 and 3.3
11	7.1 and 7.5
12	13.7
13	13.5 and 13.7
14	15.7
15	31 and 33 and 35 and 37
16	39
17	41.3
18	41.1
19	43
20	45
21	47.1
22	47.3
23	5 and 7.3
24	17.1 and 17.3
25	49.1 and 49.3
26	15.1 and 15.3 and 15.5 and 15.7 and 15.9
27	13.5 and 13.6 and 13.7
28	19
29	21
30	23
31	25
32	25
33	25
34	27
35	29
36	45 and 51
37	55.3
40	9.7 and 9.8
41	9.5

45	53
50	55.1 and 57
51	57
52	57
55	59
60	61.1 and 61.3
61	61.7 and 63.1
62	63.3
63	65
64	67
65	69.1
66	69.3
67	69.1
70	73
71	71
72	71
73	71 and 85
74	71
75	81
80	85
85	77
90	71
91	71
92	71
93	71
95	71
99	81

Conversion table FROM NACE-CLIO to NACE-BEL

NACE-CLIO CODE	CODES NACE-BEL
1	1 and 2 and 5
3.1	10
3.3	10
5	23
7.1	11
7.3	23
7.5	11
9.5	41
9.7	40
9.8	40
13.5	13 and 27
13.6	27
13.7	12 and 13 and 27
15.1	26
15.3	26
15.5	26
15.7	14 and 26
15.9	26
17.1	24
17.3	24
19	28
21	29
23	30
25	31 and 32 and 33
27	34
29	35
31	15
33	15
35	15
37	15
39	16
41.1	18
41.3	17
43	19

45	20 and 36
47.1	21
47.3	22
49.1	25
49.3	25
51	36
53	45
55.1	50
55.3	37
57	50 and 51 and 52
59	55
61.1	60
61.3	60
61.7	61
63.1	61
63.3	62
65	63
67	64
69.1	65 and 67
69.3	66
71	71. 72..73..74..90..91..92..93..95
73	70
77	85
81	75 and 99
85	73 and 80

5.5. Sectoral and regional disaggregation of the model GreenMod

	Classification of the production sectors in GreenMod	ESA 1995, A60	Code NACE[14] Rev. 1
1	Agriculture, forestry and fishing	Agriculture, hunting and related service activities	01
		Forestry, logging and related services activities	02
		Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing	05
2	Mining of coal and lignite; extraction of peat	Mining of coal and lignite; extraction of peat	10
3	Extraction of crude petroleum; service activities incidental to oil extraction excluding surveying	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	11[15]
4	Extraction of natural gas; service activities incidental to gas extraction excluding surveying	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	11[16]
5	Other mining and quarrying	Mining of uranium and thorium ores	12
		Mining of metal ores	13
		Other mining and quarrying	14
6	Manufacture of food products and beverages; tobacco	Manufacture of food products and beverages	15
		Manufacture of tobacco products	16
7	Manufacture of textile and leather products	Manufacture of textiles	17
		Manufacture of wearing apparel; dressing and dyeing of fur	18
		Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19
8	Manufacture of wood and products of wood; paper and paper products; publishing and printing; manufacture of rubber and plastic products	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20
		Manufacture of pulp, paper and paper products	21
		Publishing, printing and reproduction of recorded media	22
		Manufacture of rubber and plastic products	25
9	Manufacture of coke, refined petroleum products and nuclear fuel	Manufacture of coke, refined petroleum products and nuclear fuel	23
10	Manufacture of chemicals and chemical products	Manufacture of chemicals and chemical products	24
11	Manufacture of other non-metallic mineral products	Manufacture of other non-metallic mineral products	26
12	Manufacture of basic metals; manufacture of fabricated metal products	Manufacture of basic metals	27
		Manufacture of fabricated metal products, except machinery and equipment	28
13	Other manufacturing	Manufacture of machinery and equipment n.e.c.	29
		Manufacture of office machinery and computers	30
		Manufacture of electrical machinery and apparatus n.e.c.	31
		Manufacture of radio, television and communication equipment and apparatus	32
		Manufacture of medical, precision and optical instruments, watches and clocks	33
		Manufacture of motor vehicles, trailers and semi-trailers	34
		Manufacture of other transport equipment	35
		Manufacture of furniture; manufacturing n.e.c.	36

[14] NACE stands for the European Nomenclature Générale des Activités Economique dans les Communautés Europeeanes.
[15] Partially.
[16] Partially.

14	Electricity, gas, steam and hot water supply	Electricity, gas, steam and hot water supply	40
15	Construction	Construction	45
16	Trade, hotels, restaurants and repair	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50
		Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
		Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52
		Hotels and restaurants	55
17	Land transport; transport via pipelines	Land transport; transport via pipelines	60
18	Water transport	Water transport	61
19	Air transport	Air transport	62
20	Supporting and auxiliary transport activities; activities of travel agencies	Supporting and auxiliary transport activities; activities of travel agencies	63
21	Financial intermediation	Financial intermediation, except insurance and pension funding	65
		Insurance and pension funding, except compulsory social security	66
		Activities auxiliary to financial intermediation	67
22	Real estate activities	Real estate activities	70
23	Public administration and defence; compulsory social security	Public administration and defence; compulsory social security	75
24	Education	Education	80
25	Health and social work	Health and social work	85
26	Other services	Recycling	37
		Collection, purification and distribution of water	41
		Post and telecommunications	64
		Renting of machinery and equipment without operator and of personal and household goods	71
		Computer and related activities	72
		Research and development	73
		Other business activities	74
		Sewage and refuse disposal, sanitation and similar activities	90
		Activities of membership organizations n.e.c.	91
		Recreational, cultural and sporting activities	92
		Other service activities	93
		Private households with employed persons	95

5.6. Equations of the current version of GreenMod

5.6.1. Households

$$(1+\mathbf{vat}_{i,r}+\mathbf{tc}_{i,r}+\mathbf{tcf}_{i,r}-\mathbf{tsc}_{i,r}-\mathbf{tscf}_{i,r})\cdot\mathbf{P}_{i,r}\cdot\mathbf{C}_{i,r}=(1+\mathbf{vat}_{i,r}+ \\ +\mathbf{tc}_{i,r}+\mathbf{tcf}_{i,r}-\mathbf{tsc}_{i,r}-\mathbf{tscf}_{i,r})\cdot\mathbf{P}_{i,r}\cdot\mathbf{muH}_{i,r}+\mathbf{alphaH}_{i,r}\cdot \\ \cdot(\mathbf{CBUD}_{r}-\sum_{ii=1}^{26}\mathbf{muH}_{ii,r}\cdot(1+\mathbf{vat}_{ii,r}+\mathbf{tc}_{ii,r}+\mathbf{tcf}_{ii,r}-\mathbf{tsc}_{ii,r}-\mathbf{tscf}_{ii,r})\cdot\mathbf{P}_{ii,r}) \tag{5.6.1}$$

$$(1-\mathbf{ty}_{r}-\mathbf{tyf}_{r})\cdot\mathbf{PL}_{r}\cdot\mathbf{C}_{L,r}=(1-\mathbf{ty}_{r}-\mathbf{tyf}_{r})\cdot\mathbf{PL}_{r}\cdot\mathbf{muH}_{L,r}+ \\ +\mathbf{alphaH}_{L,r}/(1-\mathbf{alphaH}_{L,r})\cdot(\mathbf{CBUD}_{r}- \\ -\sum_{ii=1}^{26}\mathbf{muH}_{ii,r}\cdot(1+\mathbf{vat}_{ii,r}+\mathbf{tc}_{ii,r}+\mathbf{tcf}_{ii,r}-\mathbf{tsc}_{ii,r}-\mathbf{tscf}_{ii,r})\cdot\mathbf{P}_{ii,r}) \tag{5.6.2}$$

$$\mathbf{LSR}_{r}=\mathbf{TS}_{r}-\mathbf{C}_{L,r} \tag{5.6.3}$$

$$\mathbf{SH}_{r}=\mathbf{mps}_{r}\cdot(1-\mathbf{ty}_{r}-\mathbf{tyf}_{r})\cdot\mathbf{YH}_{r} \tag{5.6.4}$$

$$\mathbf{INDEX}_{r}=(\sum_{i=1}^{26}(1+\mathbf{vat}_{i,r}+\mathbf{tc}_{i,r}+\mathbf{tcf}_{i,r}-\mathbf{tsc}_{i,r}-\mathbf{tscf}_{i,r})\cdot\mathbf{P}_{i,r}\cdot\mathbf{CZ}_{i,r})/ \\ /(\sum_{i=1}^{26}(1+\mathbf{vat0}_{i,r}+\mathbf{tc0}_{i,r}+\mathbf{tcf0}_{i,r}-\mathbf{tsc0}_{i,r}-\mathbf{tscf0}_{i,r})\cdot\mathbf{PZ}_{i,r}\cdot\mathbf{CZ}_{i,r} \tag{5.6.5}$$

$$\mathbf{CPI}=(\sum_{i=1}^{26}\sum_{r=1}^{3}(1+\mathbf{vat}_{i,r}+\mathbf{tc}_{i,r}+\mathbf{tcf}_{i,r}-\mathbf{tsc}_{i,r}-\mathbf{tscf}_{i,r})\cdot\mathbf{P}_{i,r}\cdot\mathbf{CZ}_{i,r})/ \\ /(\sum_{i=1}^{26}\sum_{r=1}^{3}(1+\mathbf{vat0}_{i,r}+\mathbf{tc0}_{i,r}+\mathbf{tcf0}_{i,r}-\mathbf{tsc0}_{i,r}-\mathbf{tscf0}_{i,r})\cdot\mathbf{PZ}_{i,r}\cdot\mathbf{CZ}_{i,r}) \tag{5.6.6}$$

$$(\mathbf{PL}_{r}/\mathbf{INDEX}_{r})/(\mathbf{PLZ}_{r}/\mathbf{INDEXZ}_{r})-1=\mathbf{beta}_{r}\cdot((\mathbf{UNEMP}_{r}/\mathbf{LSR}_{r})/ \\ /(\mathbf{UNEMPZ}_{r}/\mathbf{LSRZ}_{r})-1) \tag{5.6.7}$$

5.6.2. Firms

$$\mathbf{KE}_{i,r}=(\mathbf{KLE}_{i,r}/\mathbf{A}_{i,r}^{\mathbf{KLE}})\cdot(\mathbf{gammaF}_{i,r}/\mathbf{PKE}_{r})^{\mathbf{sigmaF}_{i,r}}\cdot(\mathbf{gammaF}_{i,r}^{\mathbf{sigmaF}_{i,r}} \\ \cdot\mathbf{PKE}_{r}^{(1-\mathbf{sigmaF}_{i,r})}+(1-\mathbf{gammaF}_{i,r})^{\mathbf{sigmaF}_{i,r}}\cdot \\ \cdot((1+\mathbf{tl}_{i,r})\cdot\mathbf{PL}_{r})^{(1-\mathbf{sigmaF}_{i,r})})^{(\mathbf{sigmaF}_{i,r}/(1-\mathbf{sigmaF}_{i,r}))} \tag{5.6.8}$$

$$\mathbf{L}_{i,r}=(\mathbf{KLE}_{i,r}/\mathbf{A}_{i,r}^{\mathbf{KLE}})\cdot((1-\mathbf{gammaF}_{i,r})/((1+\mathbf{tl}_{i,r})\cdot\mathbf{PL}_{r}))^{\mathbf{sigmaF}_{i,r}}\cdot \\ \cdot(\mathbf{gammaF}_{i,r}^{\mathbf{sigmaF}_{i,r}}\cdot\mathbf{PKE}_{r}^{(1-\mathbf{sigmaF}_{i,r})}+(1-\mathbf{gammaF}_{i,r})^{\mathbf{sigmaF}_{i,r}}\cdot \\ \cdot((1+\mathbf{tl}_{i,r})\cdot\mathbf{PL}_{r})^{(1-\mathbf{sigmaF}_{i,r})})^{(\mathbf{sigmaF}_{i,r}/(1-\mathbf{sigmaF}_{i,r}))} \tag{5.6.9}$$

$$\begin{aligned}\mathbf{K_{i,r}} &= (\mathbf{KE_{i,r}}/\mathbf{A_{i,r}^{KE}})\cdot(\mathbf{gammaKE_{i,r}}/((1+\mathbf{tk_{i,r}}+\mathbf{tkf_{i,r}})\cdot\mathbf{PK_r}\cdot\\ &\cdot\mathbf{rdiff_{i,r}}))^{\mathbf{sigmaKE_{i,r}}}\cdot(\mathbf{gammaKE_{i,r}}^{\mathbf{sigmaKE_{i,r}}}\cdot((1+\mathbf{tk_{i,r}}+\mathbf{tkf_{i,r}})\cdot\\ &\cdot\mathbf{PK_r}\cdot\mathbf{rdiff_{i,r}})^{(1-\mathbf{sigmaKE_{i,r}})}+(1-\mathbf{gammaKE_{i,r}})^{\mathbf{sigmaKE_{i,r}}}\cdot\\ &\cdot\mathbf{PEN_r}^{(1-\mathbf{sigmaKE_{i,r}})})^{(\mathbf{sigmaKE_{i,r}}/(1-\mathbf{sigmaKE_{i,r}}))}\end{aligned} \tag{5.6.10}$$

$$\begin{aligned}\mathbf{EN_{i,r}} &= (\mathbf{KE_{i,r}}/\mathbf{A_{i,r}^{KE}})\cdot((1-\mathbf{gammaKE_{i,r}})/\mathbf{PEN_r})^{\mathbf{sigmaKE_{i,r}}}\cdot\\ &\cdot(\mathbf{gammaKE_{i,r}}^{\mathbf{sigmaKE_{i,r}}}\cdot((1+\mathbf{tk_{i,r}}+\mathbf{tkf_{i,r}})\cdot\mathbf{PK_r}\cdot\mathbf{rdiff_{i,r}})^{(1-\mathbf{sigmaKE_{i,r}})}+\\ &+(1-\mathbf{gammaKE_{i,r}})^{\mathbf{sigmaKE_{i,r}}}\cdot\mathbf{PEN_r}^{(1-\mathbf{sigmaKE_{i,r}})})^{(\mathbf{sigmaKE_{i,r}}/(1-\mathbf{sigmaKE_{i,r}}))}\end{aligned} \tag{5.6.11}$$

$$\begin{aligned}\mathbf{EI_{e,i,r}} &= (\mathbf{EN_{i,r}}/\mathbf{A_{i,r}^{E}})\cdot(\mathbf{gammaKE_{e,i,r}}/\mathbf{PEN_r})^{\mathbf{sigmaE_{i,r}}}\cdot\\ &\cdot[\sum_{\mathbf{e=1}}^{5}\mathbf{gammaE_{e,i,r}}^{\mathbf{sigmaE_{i,r}}}\cdot((1+\mathbf{te_{e,i,r}})\cdot\mathbf{P_{e,r}})^{(1-\mathbf{sigmaE_{i,r}})}]^{(\mathbf{sigmaE_{i,r}}/(1-\mathbf{sigmaE_{i,r}}))}\end{aligned} \tag{5.6.12}$$

$$\begin{aligned}\mathbf{SF_r} &= (1-\mathbf{aich_r})\cdot(\sum_{\mathbf{i=1}}^{26}((1-\mathbf{d_{i,r}})\cdot\mathbf{K_{i,r}}\cdot\mathbf{PK_r}\cdot\mathbf{diff_{i,r}})+\mathbf{TRFG_r}\cdot\mathbf{INDEX_r}+\\ &+\mathbf{TRFFG_r}\cdot\mathbf{INDEX_r}+\mathbf{ER}\cdot\mathbf{TRFW_r}\end{aligned} \tag{5.6.13}$$

5.6.3. Federal Government

$$\begin{aligned}\mathbf{TAXRF} &= \sum_{\mathbf{r=1}}^{3}\mathbf{tyf_r}\cdot\mathbf{YH_r}+\sum_{\mathbf{i=1}}^{26}\sum_{\mathbf{r=1}}^{3}(\mathbf{vat_{i,r}}+\mathbf{tcf_{i,r}}-\mathbf{tscf_{i,r}})\cdot\mathbf{P_{i,r}}\cdot\mathbf{C_{i,r}}+\\ &+\sum_{\mathbf{i=1}}^{26}\sum_{\mathbf{r=1}}^{3}(\mathbf{tkf_{i,r}}\cdot(1-\mathbf{d_{i,r}})\cdot\mathbf{K_{i,r}}\cdot\mathbf{PK_r}\cdot\mathbf{rdiff_{i,r}}+\mathbf{tl_{i,r}}\cdot\mathbf{L_{i,r}}\cdot\mathbf{PL_r}+\\ &+\mathbf{tm_{i,r}}\cdot\mathbf{M_{i,r}}\cdot\mathbf{PWMZ_i}\cdot\mathbf{ER}+\mathbf{XD_{i,r}}\cdot\mathbf{PD_{i,r}}\cdot(\mathbf{tpf_{i,r}}-\mathbf{tspf_{i,r}}))+\\ &+\sum_{\mathbf{e=1}}^{5}\sum_{\mathbf{r=1}}^{3}\mathbf{te_{e,i,r}}\cdot\mathbf{EI_{e,i,r}}\cdot\mathbf{P_{e,r}}\end{aligned} \tag{5.6.14}$$

$$\mathbf{TRHFG_r} = \mathbf{trep_r}\cdot\mathbf{PL_r}\cdot\mathbf{UNEMP_r}+\mathbf{TRO_r}\cdot\mathbf{INDEX_r} \tag{5.6.15}$$

$$\begin{aligned}\mathbf{CFGBUD} &= \mathbf{TAXRF}-\mathbf{TRFCFG}\cdot\mathbf{CPI}-\mathbf{SFGT}\cdot\mathbf{CPI}-\mathbf{TRWFG}\cdot\mathbf{ER}-\\ &-\sum_{\mathbf{r=1}}^{3}(\mathbf{TRFFG_r}\cdot\mathbf{INDEX_r}+\mathbf{TRHFG_r}+\mathbf{TRGFG_r}\cdot\mathbf{INDEX_r})\end{aligned} \tag{5.6.16}$$

$$\mathbf{P_{i,r}}\cdot\mathbf{CFG_{i,r}} = \mathbf{alphaFG_{i,r}}\cdot\mathbf{CFGBUD} \tag{5.6.17}$$

5.6.4. Regional government

$$\begin{aligned}\mathbf{TAXR_r} &= \mathbf{ty_r}\cdot\mathbf{YH_r}+\sum_{\mathbf{i=1}}^{26}((\mathbf{tc_{i,r}}-\mathbf{tsc_{i,r}})\cdot\mathbf{P_{i,r}}\cdot\mathbf{C_{i,r}}+\\ &+\mathbf{tk_{i,r}}\cdot(1-\mathbf{d_{i,r}})\cdot\mathbf{K_{i,r}}\cdot\mathbf{PK_r}\cdot\mathbf{rdiff_{i,r}}+\mathbf{XD_{i,r}}\cdot\mathbf{PD_{i,r}}\cdot(\mathbf{tp_{i,r}}-\mathbf{tsp_{i,r}}))\end{aligned} \tag{5.6.18}$$

$$\begin{aligned}\mathbf{CGBUD_r} &= \mathbf{TAXR_r} + \mathbf{TRGFC_r}\cdot\mathbf{INDEX_r} + \mathbf{TRGFG_r}\cdot\mathbf{INDEX_r} - \\ &- \mathbf{TRHG_r}\cdot\mathbf{INDEX_r} - \mathbf{TRFG_r}\cdot\mathbf{INDEX_r} - \mathbf{ER}\cdot\mathbf{TRWG_r} - \mathbf{SG_r}\cdot\mathbf{INDEX_r}\end{aligned} \tag{5.6.19}$$

$$\mathbf{P_{i,r}}\cdot\mathbf{CG_{i,r}} = \mathbf{alphaG_{i,r}}\cdot\mathbf{CGBUD_r} \tag{5.6.20}$$

5.6.5. French Community

$$\mathbf{CFCBUD} = \mathbf{TRFCFG}\cdot\mathbf{CPI} - \mathbf{TRGFC_{wal}}\cdot\mathbf{INDEX_{wal}} \tag{5.6.21}$$

$$\mathbf{P_{i,r}}\cdot\mathbf{CFC_{i,r}} = \mathbf{alphaFC_{i,r}}\cdot\mathbf{CFCBUD} \tag{5.6.22}$$

5.6.6. Inter-regional and foreign trade

$$\mathbf{PE_r} = \mathbf{PWEZ_r}\cdot\mathbf{ER} \tag{5.6.23}$$

$$\begin{aligned}\mathbf{E_{i,r}} &= (\mathbf{XD_{i,r}}/\mathbf{aT_{i,r}})\cdot(\mathbf{gammaT1_{i,r}}/\mathbf{PE_i})^{\mathbf{sigmaT_{i,r}}}\cdot(\mathbf{gammaT1_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PE_i}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT2_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDE_{i,r,rr+1}}^{(1-\mathbf{sigmaT_{i,r}})} + \\ &+ \mathbf{gammaT3_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDE_{i,r,rr+2}}^{(1-\mathbf{sigmaT_{i,r}})} + (1-\mathbf{gammaT1_{i,r}} - \\ &- \mathbf{gammaT2_{i,r}} - \mathbf{gammaT3_{i,r}})^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDD_{i,r}}^{(1-\mathbf{sigmaT_{i,r}})})^{(\mathbf{sigmaT_{i,r}}/(1-\mathbf{sigmaT_{i,r}}))}\end{aligned} \tag{5.6.24}$$

$$\begin{aligned}\mathbf{EM_{i,r,rr+1}} &= (\mathbf{XD_{i,r}}/\mathbf{aT_{i,r}})\cdot(\mathbf{gammaT2_{i,r}}/\mathbf{PDE_{i,r,rr+1}})^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot(\mathbf{gammaT1_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PE_i}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT2_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PDE_{i,r,rr+1}}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT3_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDE_{i,r,rr+2}}^{(1-\mathbf{sigmaT_{i,r}})} + \\ &+ (1-\mathbf{gammaT1_{i,r}} - \mathbf{gammaT2_{i,r}} - \mathbf{gammaT3_{i,r}})^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PDD_{i,r}}^{(1-\mathbf{sigmaT_{i,r}})})^{(\mathbf{sigmaT_{i,r}}/(1-\mathbf{sigmaT_{i,r}}))}\end{aligned} \tag{5.6.25}$$

$$\begin{aligned}\mathbf{EM_{i,r,rr+2}} &= (\mathbf{XD_{i,r}}/\mathbf{aT_{i,r}})\cdot(\mathbf{gammaT3_{i,r}}/\mathbf{PDE_{i,r,rr+2}})^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot(\mathbf{gammaT1_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PE_i}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT2_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PDE_{i,r,rr+1}}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT3_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PDE_{i,r,rr+2}}^{(1-\mathbf{sigmaT_{i,r}})} + (1-\mathbf{gammaT1_{i,r}} - \mathbf{gammaT2_{i,r}} - \\ &- \mathbf{gammaT3_{i,r}})^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDD_{i,r}}^{(1-\mathbf{sigmaT_{i,r}})})^{(\mathbf{sigmaT_{i,r}}/(1-\mathbf{sigmaT_{i,r}}))}\end{aligned} \tag{5.6.26}$$

$$\begin{aligned}\mathbf{XDD_{i,r}} &= (\mathbf{XD_{i,r}}/\mathbf{aT_{i,r}})\cdot((1-\mathbf{gammaT1_{i,r}} - \mathbf{gammaT2_{i,r}} - \\ &- \mathbf{gammaT3_{i,r}})/\mathbf{PDD_{i,r}})^{\mathbf{sigmaT_{i,r}}}\cdot(\mathbf{gammaT1_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PE_i}^{(1-\mathbf{sigmaT_{i,r}})} + \\ &+ \mathbf{gammaT2_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDE_{i,r,rr+1}}^{(1-\mathbf{sigmaT_{i,r}})} + \mathbf{gammaT3_{i,r}}^{\mathbf{sigmaT_{i,r}}}\cdot \\ &\cdot\mathbf{PDE_{i,r,rr+2}}^{(1-\mathbf{sigmaT_{i,r}})} + (1-\mathbf{gammaT1_{i,r}} - \mathbf{gammaT2_{i,r}} - \\ &- \mathbf{gammaT3_{i,r}})^{\mathbf{sigmaT_{i,r}}}\cdot\mathbf{PDD_{i,r}}^{(1-\mathbf{sigmaT_{i,r}})})^{(\mathbf{sigmaT_{i,r}}/(1-\mathbf{sigmaT_{i,r}}))}\end{aligned} \tag{5.6.27}$$

$$\mathbf{PM_{i,r}} = (1+\mathbf{tm_{i,r}})\cdot\mathbf{ER}\cdot\mathbf{PWMZ_i} \tag{5.6.28}$$

$$\mathbf{M_{i,r} = (X_{i,r}/aA_{i,r}) \cdot (gammaA1_{i,r}/PM_{i,r})^{sigmaA_{i,r}} \cdot (gammaA1_{i,r}^{sigmaA_{i,r}} \cdot PM_{i,r}^{(1-sigmaA_{i,r})} + gammaA2_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+1,r}^{(1-sigmaA_{i,r})} + gammaA3_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+2,r}^{(1-sigmaA_{i,r})} + (1-gammaA1_{i,r}-gammaA2_{i,r}-gammaA3_{i,r})^{sigmaA_{i,r}} \cdot PDD_{i,r}^{(1-sigmaA_{i,r})})^{(sigmaA_{i,r}/(1-sigmaA_{i,r}))}} \quad (5.6.29)$$

$$\mathbf{ME_{i,rr+1,r} = (X_{i,r}/aA_{i,r}) \cdot (gammaA2_{i,r}/PDM_{i,rr+1,r})^{sigmaA_{i,r}} \cdot (gammaA1_{i,r}^{sigmaA_{i,r}} \cdot PM_{i,r}^{(1-sigmaA_{i,r})} + gammaA2_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+1,r}^{(1-sigmaA_{i,r})} + gammaA3_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+2,r}^{(1-sigmaA_{i,r})} + (1-gammaA1_{i,r}-gammaA2_{i,r}-gammaA3_{i,r})^{sigmaA_{i,r}} \cdot PDD_{i,r}^{(1-sigmaA_{i,r})})^{(sigmaA_{i,r}/(1-sigmaA_{i,r}))}} \quad (5.6.30)$$

$$\mathbf{ME_{i,rr+2,r} = (X_{i,r}/aA_{i,r}) \cdot (gammaA3_{i,r}/PDM_{i,rr+2,r})^{sigmaA_{i,r}} \cdot (gammaA1_{i,r}^{sigmaA_{i,r}} \cdot PM_{i,r}^{(1-sigmaA_{i,r})} + gammaA2_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+1,r}^{(1-sigmaA_{i,r})} + gammaA3_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+2,r}^{(1-sigmaA_{i,r})} + (1-gammaA1_{i,r}-gammaA2_{i,r}-gammaA3_{i,r})^{sigmaA_{i,r}} \cdot PDD_{i,r}^{(1-sigmaA_{i,r})})^{(sigmaA_{i,r}/(1-sigmaA_{i,r}))}} \quad (5.6.31)$$

$$\mathbf{XDD_{i,r} = (X_{i,r}/aA_{i,r}) \cdot ((1-gammaA1_{i,r}-gammaA2_{i,r}-gammaA3_{i,r})/PDD_{i,r})^{sigmaA_{i,r}} \cdot (gammaA1_{i,r}^{sigmaA_{i,r}} \cdot PM_{i,r}^{(1-sigmaA_{i,r})} + gammaA2_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+1,r}^{(1-sigmaA_{i,r})} + gammaA3_{i,r}^{sigmaA_{i,r}} \cdot PDM_{i,rr+2,r}^{(1-sigmaA_{i,r})} + (1-gammaA1_{i,r}-gammaA2_{i,r}-gammaA3_{i,r})^{sigmaA_{i,r}} \cdot PDD_{i,r}^{(1-sigmaA_{i,r})})^{(sigmaA_{i,r}/(1-sigmaA_{i,r}))}} \quad (5.6.32)$$

$$\mathbf{PDE_{i,r,rr+1} = PDM_{i,r,rr+1}} \quad (5.6.33)$$

$$\mathbf{PDE_{i,r,rr+2} = PDM_{i,r,rr+2}} \quad (5.6.34)$$

$$\mathbf{EM_{i,r,rr+1} = ME_{i,r,rr+1}} \quad (5.6.35)$$

$$\mathbf{EM_{i,r,rr+2} = ME_{i,r,rr+2}} \quad (5.6.36)$$

$$\mathbf{SWT = \sum_{i=1}^{26}\sum_{r=1}^{3}(E_{i,r} \cdot PWEZ_i - M_{i,r} \cdot PWMZ_i) + \sum_{r=1}^{3}(TRFW_r + LW_r \cdot PLWZ) - \sum_{r=1}^{3}(TRWG_r + TRWH_r) - TRWFG} \quad (5.6.37)$$

5.6.7. Investment

$$\mathbf{S} = \sum_{\mathbf{r}=1}^{3}(\mathbf{SH}_{\mathbf{r}} + \mathbf{SG}_{\mathbf{r}} \cdot \mathbf{INDEX}_{\mathbf{r}} + \mathbf{SF}_{\mathbf{r}}) + \mathbf{SFGT} \cdot \mathbf{CPI} + \mathbf{SWT} \cdot \mathbf{ER} + \\ + \sum_{\mathbf{i}=1}^{26}\sum_{\mathbf{r}=1}^{3}\mathbf{DEP}_{\mathbf{i,r}} \cdot \mathbf{P}_{\mathbf{i,r}} \quad (5.6.38)$$

$$\mathbf{DEP}_{\mathbf{i,r}} = \mathbf{d}_{\mathbf{i,r}} \cdot \mathbf{K}_{\mathbf{i,r}} \quad (5.6.39)$$

$$\mathbf{SV}_{\mathbf{ix,r}} = \mathbf{svr}_{\mathbf{ix,r}} \cdot \mathbf{XD}_{\mathbf{ix,r}} \quad (5.6.40)$$

$$\mathbf{SV}_{\mathbf{im,r}} = \mathbf{svr}_{\mathbf{im,r}} \cdot \mathbf{M}_{\mathbf{im,r}} \quad (5.6.41)$$

$$\mathbf{P}_{\mathbf{i,r}} \cdot \mathbf{I}_{\mathbf{i,r}} = \mathbf{alphaI}_{\mathbf{i,r}} \cdot (\mathbf{S} - \sum_{\mathbf{imm}}\sum_{\mathbf{rr}=1}^{3}\mathbf{SV}_{\mathbf{imm,rr}} \cdot \mathbf{P}_{\mathbf{ii,rr}} - \sum_{\mathbf{ixx}}\sum_{\mathbf{rr}=1}^{3}\mathbf{SV}_{\mathbf{ixx,rr}} \cdot \mathbf{P}_{\mathbf{ii,rr}}) \quad (5.6.42)$$

5.6.8. Market clearing

$$\sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,wal}} = \mathbf{LSR}_{\mathbf{wal}} - \mathbf{shWBx} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,bxl}} - \mathbf{shWFl} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,fla}} - \mathbf{UNEMP}_{\mathbf{wal}} \quad (5.6.43)$$

$$\sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,fla}} = \mathbf{LSR}_{\mathbf{fla}} - \mathbf{shFlBx} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,bxl}} + \mathbf{shWFl} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,fla}} - \mathbf{UNEMP}_{\mathbf{fla}} \quad (5.6.44)$$

$$\sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,bxl}} = \mathbf{LSR}_{\mathbf{bxl}} + \mathbf{shWBx} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,bxl}} + \mathbf{shFlBx} \cdot \sum_{\mathbf{i}=1}^{26}\mathbf{L}_{\mathbf{i,bxl}} - \mathbf{UNEMP}_{\mathbf{bxl}} \quad (5.6.45)$$

$$\mathbf{LS}_{\mathbf{r}} = \mathbf{LSR}_{\mathbf{r}} + \mathbf{LW}_{\mathbf{r}} \quad (5.6.46)$$

$$\sum_{\mathbf{i}=1}^{26}(\mathbf{1} - \mathbf{d}_{\mathbf{i,r}}) \cdot \mathbf{K}_{\mathbf{i,r}} = \mathbf{KS}_{\mathbf{r}} \quad (5.6.47)$$

$$\mathbf{C}_{\mathbf{ne,r}} + \mathbf{I}_{\mathbf{ne,r}} + \mathbf{SV}_{\mathbf{ne,r}} + \sum_{\mathbf{i}=1}^{26}\mathbf{io}_{\mathbf{ne,i,r}} \cdot \mathbf{XD}_{\mathbf{i,r}} + \mathbf{CG}_{\mathbf{ne,r}} + \mathbf{CFG}_{\mathbf{ne,r}} + \mathbf{CFC}_{\mathbf{ne,r}} = \mathbf{X}_{\mathbf{ne,r}} \quad (5.6.48)$$

$$\mathbf{C}_{\mathbf{e,r}} + \mathbf{I}_{\mathbf{e,r}} + \mathbf{SV}_{\mathbf{e,r}} + \sum_{\mathbf{i}=1}^{26}\mathbf{EI}_{\mathbf{e,i,r}} + \mathbf{CG}_{\mathbf{e,r}} + \mathbf{CFG}_{\mathbf{e,r}} + \mathbf{CFC}_{\mathbf{e,r}} = \mathbf{X}_{\mathbf{e,r}} \quad (5.6.49)$$

5.6.9. CO_2 emissions

$$\mathbf{CO2EMIS}_{\mathbf{i,r}} = \sum_{\mathbf{en}=1}^{5}\mathbf{CO2GJ}_{\mathbf{en,i,r}} \cdot \mathbf{GJOULE}_{\mathbf{en,r}} \cdot (\mathbf{X}_{\mathbf{en,r}} - \mathbf{SV}_{\mathbf{en,r}}) \cdot \mathbf{CO2SCAL}_{\mathbf{i,r}} \quad (5.6.50)$$

5.6.10. Income definitions and zero profit conditions

$$\mathbf{YH}_{\mathbf{r}} = \mathbf{aich}_{\mathbf{r}} \cdot \sum_{\mathbf{i}=1}^{26}(\mathbf{1} - \mathbf{d}_{\mathbf{i,r}}) \cdot \mathbf{K}_{\mathbf{i,r}} \cdot \mathbf{PK}_{\mathbf{r}} \cdot \mathbf{rdiff}_{\mathbf{i,r}} + \mathbf{PL}_{\mathbf{r}} \cdot (\mathbf{LSR}_{\mathbf{r}} - \mathbf{UNEMP}_{\mathbf{r}}) + \\ + \mathbf{PLWZ} \cdot \mathbf{ER} \cdot \mathbf{LW}_{\mathbf{r}} + \mathbf{TRHG}_{\mathbf{r}} \cdot \mathbf{INDEX}_{\mathbf{r}} + \mathbf{TRHFG}_{\mathbf{r}} - \mathbf{ER} \cdot \mathbf{TRWH}_{\mathbf{r}} \quad (5.6.51)$$

$$\mathbf{CBUD_r = YH_r - ty_r \cdot YH_r - tyf_r \cdot YH_r - SH_r} \quad (5.6.52)$$

$$\mathbf{P_{i,r} \cdot X_{i,r} = PM_{i,r} \cdot M_{i,r} + PDM_{i,rr+1,r} \cdot ME_{i,rr+1,r} + PDM_{i,rr+2,r} \cdot ME_{i,rr+2,r} + + PDD_{i,r} \cdot XDD_{i,r}} \quad (5.6.53)$$

$$\mathbf{PD_{i,r} \cdot XD_{i,r} = PE_i \cdot E_{i,r} + PDE_{i,r,rr+1} \cdot EM_{i,r,rr+1} + PDE_{i,r,rr+2} \cdot EM_{i,r,rr+2} + + PDD_{i,r} \cdot XDD_{i,r}} \quad (5.6.54)$$

$$\mathbf{PKLE_{i,r} \cdot KLE_{i,r} = PKE_{i,r} \cdot KE_{i,r} + (1 + tl_{i,r}) \cdot PL_r \cdot L_{i,r}} \quad (5.6.55)$$

$$\mathbf{(1 - tp_{i,r} - tpf_{i,r} + tsp_{i,r} + tspf_{i,r}) \cdot PD_{i,r} = aKLE_{i,r} \cdot PKLE_{i,r} + \sum_{ne} io_{ne,i,r} \cdot P_{ne,r}} \quad (5.6.56)$$

$$\mathbf{PKE_{i,r} \cdot KE_{i,r} = (1 + tk_{i,r} + tkf_{i,r}) \cdot PK_r \cdot rdiff_{i,r} \cdot (1 - d_{i,r}) \cdot K_{i,r} + DEP_{i,r} \cdot PD_{i,r} + PEN_{i,r} \cdot EN_{i,r}} \quad (5.6.57)$$

$$\mathbf{PEN_{i,r} \cdot EN_{i,r} = \sum_{en=1}^{5} EI_{en,i,r} \cdot P_{en,r} \cdot (1 + te_{en,i,r})} \quad (5.6.58)$$

5.6.11. List of variables

ER	exchange rate
CPI	consumer price index at the national level
PK_r	average return to capital by region
PL_r	average return to labour by region
$INDEX_r$	regional consumer price index
$P_{i,r}$	consumer price of domestic composite good before taxes, by region
$PD_{i,r}$	production price of domestic good, by region
$PDE_{i,r,rr}$	price of exports to the other Belgian regions
$PDM_{i,r,rr}$	price of imports from the other Belgian regions
$PDD_{i,r}$	price level of domestic good delivered to the domestic market, by region
PE_i	domestic price of exports to the rest of the world
$PM_{i,r}$	domestic price of imports from the rest of the world
$PWEZ_i$	world price of exports
$PWMZ_i$	world price of imports
$PKLE_{i,r}$	average return to capital-labour-energy bundle by region
$PKE_{i,r}$	average return to capital-energy bundle by region
$PEN_{i,r}$	price of energy composite by region
CFGBUD	federal government disposable budget for consumption
CFCBUD	French community disposable budget for consumption
TRFCFG	transfers received by the French community from the federal government
TRWFG	transfers of the federal government to the rest of the world

TAXRF	tax revenue of the federal government
SWT	foreign savings
S	total saving at the national level
SFGT	total saving of the federal government
KS_r	capital stock supply by region
LSR_r	regional supply of labour
LS_r	total supply of labour for each region and the rest of the world
YH_r	households' income by region
SH_r	households' savings by region
SF_r	firms savings by region
SG_r	regional governments' savings
$CGBUD_r$	regional government disposable budget for consumption
$CBUD_r$	household disposable budget for consumption, by region
TS_r	time endowment by region
$UNEMP_r$	unemployment by region
LW_r	labour demand from the rest of the world
$TAXR_r$	regional government tax revenue
$TRWH_r$	transfers of the households to the rest of the world by region
$TRFG_r$	transfers received by the firms from the regional government
$TRFFG_r$	transfers received by the firms from the federal government
$TRHG_r$	transfers received by the households from the regional government
$TRHFG_r$	total transfers received by the household of each region from the federal government
TRO_r	other transfers received by the households from the federal government (excluding social benefits)
$TRGFG_r$	transfers received by the regional governments from the federal government
$TRGFC_{wal}$	transfers received by the Wallonian government from the French community
TRFCFG	transfers received by the French community from the federal government
$TRWG_r$	transfers received by the rest of the world from the government
$TRFW_r$	transfers of the firms to the rest of the world
$X_{i,r}$	domestic sales by region
$XD_{i,r}$	domestic production (output) level by region
$XDD_{i,r}$	domestic production delivered to home markets, by region
$K_{i,r}$	capital stock by region
$L_{i,r}$	labour demand by region

$C_{i,r}$	consumer demand for goods by region
$C_{L,r}$	consumer demand for leisure by region
$CG_{i,r}$	regional governments demand for goods
$CFG_{i,r}$	federal government demand for goods, by type of commodity and region
$CFC_{i,r}$	French community demand for goods, by type of commodity and region
$I_{i,r}$	investment demand by commodity and region
$E_{i,r}$	export demand from the rest of the world by region
$M_{i,r}$	import demand from the rest of the world by region
$EM_{i,r,rr}$	export demand from the other Belgian regions
$ME_{i,r,rr}$	import demand from the other Belgian regions
$DEP_{i,r}$	capital stock depreciation by region
$SV_{ix,r}$	changes in stocks by region, as a share of gross output
$SV_{im,r}$	changes in stocks by region, as a share of imports
$CO2EMIS_{i,r}$	CO_2 emissions by sector and region
$CO2GJ_{e,i,r}$	kilos of CO_2 emissions per Giga joule out of energy input *e*, used by sector *i* of region *r*
$GJOULE_{e,r}$	conversion factor for energy inputs from value terms in Giga joules

5.6.12. List of parameters

$elasY\_LS_r$	income elasticity of labour supply by region
$beta_r$	parameter in the wage curve, by region
$aich_r$	share parameter of income from capital received by the households, by region
$trep_r$	replacement rate out of net wage by region
mps_r	marginal propensity to save out of households income, by region
ty_r	tax rate on households income (IPP) paid to the regional government
tyf_r	tax rate on households income paid to the federal government
$vat_{i,r}$	value added tax rate by region
$vat0_{i,r}$	initial value added tax rate on consumption goods, to be used in the derivation of CPI by region
$tc_{i,r}$	consumption tax rate paid to the regional government (other then VAT)
$tc0_{i,r}$	initial consumption tax rate paid to the regional government (other then VAT), to be used in the derivation of CPI by region
$tcf_{i,r}$	consumption tax rate paid to the federal government
$tcf0_{i,r}$	initial consumption tax rate paid to the federal government to be used in

	the derivation of CPI by region
$tsc_{i,r}$	subsidies rate on consumption (paid by the regional government)
$tsc0_{i,r}$	initial subsidies rate on consumption (paid by the regional government), to be used in the derivation of CPI by region
$tscf_{i,r}$	subsidies rate on consumption (paid by the federal government)
$tscf0_{i,r}$	subsidies rate on consumption (paid by the federal government), to be used in the derivation of CPI by region
$tk_{i,r}$	tax rate on capital use paid at the regional level
$tkf_{i,r}$	tax rate on capital use paid at the federal level
$tl_{i,r}$	tax rate on labour use paid at the federal level (social contributions)
$tp_{i,r}$	tax rate on production paid at the regional level
$tpf_{i,r}$	tax rate on production paid at the federal level
$tsp_{i,r}$	subsidies rate on production (paid by the regional government)
$tspf_{i,r}$	subsidies rate on production (paid by the federal government)
$tm_{i,r}$	tariff rate on imports by region
$te_{e,r}$	tax rate on energy inputs
$io_{i,ii,r}$	technical coefficients by region
$d_{i,r}$	depreciation rate by region
$svr_{ix,r}$	inventory investment ratios (out of gross output), by region
$svr_{im,r}$	inventory investment ratios (out of imports), by region
$?F_{i,r}$	production function share parameter (first nest)
$?KE_{i,r}$	production function share parameter (second nest)
$?E_{e,i,r}$	production function share parameter (third nest)
$a_{i,r}$	production function XD KLE parameter (first nest - Leontief)
$aKLE_{i,r}$	production function parameter (first nest)
$aKE_{i,r}$	production function parameter (second nest)
$aE_{i,r}$	production function parameter (third nest)
$?A1_{i,r}$	CES share parameter of ARMINGTON function
$?A2_{i,r}$	CES share parameter of ARMINGTON function
$?A3_{i,r}$	CES share parameter of ARMINGTON function
$aA_{i,r}$	efficiency parameter of ARMINGTON function
$?T1_{i,r}$	CET share parameter (exports)
$?T2_{i,r}$	CET share parameter (exports)
$?T3_{i,r}$	CET share parameter (exports)
$aT_{i,r}$	shift parameter in the CET function
$aH_{i,r}$	LES power in households utility function
$elasY_{i,r}$	income elasticities of demand for commodities, by region

$\mu H_{i,r}$	minimum (subsistence) levels of consumption of commodities
$aI_{i,r}$	Cobb-Douglas power in investment utility function
$aG_{i,r}$	Cobb-Douglas power in regional government utility function
$aFG_{i,r}$	Cobb-Douglas power in the federal government utility function
$aFC_{i,r}$	Cobb-Douglas power in the French community utility function
$rdiff_{i,r}$	rental rate differential between sectors, by region
$sA_{i,r}$	substitution elasticities in the CES function (ARMINGTON) by region
$sT_{i,r}$	substitution elasticities in the CET function by region
$sF_{i,r}$	CES substitution elasticities between capital-energy composite and labour (first nest)
$sKE_{i,r}$	CES substitution elasticities between capital and energy composite (second nest)
$sE_{i,r}$	CES substitution elasticities between different energy inputs (third nest)
shWBx	share of commuters from Wallonia to Bruxelles
shFlBx	share of commuters from Flandre to Bruxelles
shWFl	share of commuters from Wallonia to Flandr
$CO2SCAL_{i,r}$	scaling factor which assures the consistency with the CO_2 emissions provided by the Interregional Cell for the Environment[17] for 1997

[17] The CO2 emissions provided by the Interregional Cell for the Environment follow the guidelines of the United Nation Framework Convention on Climate Change (UNFCCC).