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**GEM-E3 SWITZERLAND:
A COMPUTABLE GENERAL EQUILIBRIUM MODEL
APPLIED FOR SWITZERLAND**

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Executive summary

The European Research Project No. JOS3-CT97-0017 *GEM-E3-ELITE*, funded by the European Commission (DGXII), took place from February 1998 to July 1999. It was co-ordinated by the Centre for European Economic Research (Germany). It involved also the Catholic University of Leuven (Belgium), the ERASME research institute (France), the University of Stuttgart (Germany), the National University of Athens (Greece), the MERIT research institute (the Netherlands), the Stockholm School of Economics (Sweden) and the Paul Scherrer Institute (PSI). The objectives of *GEM-E3-ELITE* were to further develop the general equilibrium model GEM-E3 (Capros *et al.*, 1995, 1997) and to conduct policy analysis through case studies.

GEM-E3 is an applied general equilibrium model that analyses the macro-economy and its interaction with the energy system and the environment. It follows a computable general equilibrium approach in the sense that it computes the equilibrium prices of goods, services, capital and labour that simultaneously clear all markets under the Walras Law (Walras, 1954). Interactions among the economy, energy system and environment are evaluated through the balancing of energy supply and demand, atmospheric emissions and pollution control, together with the fulfilment of overall equilibrium conditions.

The participation of PSI in the *GEM-E3-ELITE* research project, under the supervision of Socrates Kypreos, was partially funded by the Swiss Federal Office for Education and Science (*Contract Number 97.0475*). PSI's research objectives were to implement and apply GEM-E3 for Switzerland. Both objectives were completed successfully. The first objective required in particular the development of a Swiss database for each of GEM-E3 modules (economic module and environmental module). For the second objective, strategies to reduce CO₂ emissions were evaluated for Switzerland.

The development of the economic database proved to be more difficult than expected, due to the lack of some required disaggregated economic data for Switzerland. To overcome the encountered difficulties, PSI collaborated with the Laboratory of Applied Economics (LEA) of the University of Geneva and the Laboratory of Energy Systems (LASSEN) of the Federal Technical Institute of Lausanne (EPFL). The Swiss Federal Statistical Office (SFSO) and the Institute for Business Cycle Research (KOF) of the Swiss Federal Institute of Technology (ETH) contributed also data.

The GEM-E3 economic database consists mostly of a Social Accounting Matrix (SAM). To build such a matrix, PSI used a Swiss SAM constructed by LEA for the year 1990 (Guillet and Antille, 1998). This SAM is already calibrated, but its format is not consistent with the one of GEM-E3. Indeed, it uses the NGAE nomenclature with 37 sectors and 8 consumption categories, whereas GEM-E3 uses the NACE nomenclature with 18 sectors and 13 consumption categories. Furthermore, this SAM lacks many data needed in GEM-E3. PSI's work consisted thus on the one hand in transforming the LEA's SAM into the requested nomenclature, and on the other hand in completing it with additional data.

The Swiss environmental database consists mainly of an Energy Balance Table and of an Emission Coefficients Table. Both were designed using national and international

official statistics. The Emission Coefficients Table is furthermore based on know-how of the PSI GaBE Project.

Using GEM-E3 Switzerland, two strategies to reduce the Swiss CO₂ emissions were evaluated: a carbon tax ('tax only' strategy), and the combining of a carbon tax with the buying of CO₂ emission permits ('permits & tax' strategy). In the first strategy, Switzerland would impose the necessary carbon tax to achieve the reduction target, and use the tax revenue to reduce social security charges. In the second strategy, Switzerland would impose a lower carbon tax than in the first case. It would then use part of the tax revenue to acquire emission permits on an international market, so as to fulfil the reduction target. And it would use the remaining of the tax revenue to reduce social security charges as in the first strategy.

For the numerical evaluation, two scenarios were studied: i) a baseline scenario, where CO₂ emissions are not limited, and ii) a 10% CO₂ emission reduction scenario, where the abatement target is based on the 1990 emission level and is to be reached by 2010. For each scenario, two variants were considered related to technical progress and economic growth of the 'Rest of the World': i) a low growth variant and ii) a high growth variant. Furthermore, along with the reduction scenario, the two strategies *tax only* and *permits & tax* were evaluated.

Both reduction strategies yield a so-called 'double dividend', here a simultaneous improvement of the environmental quality (atmospheric pollution reduction) and of the employment level. The employment increase is higher in the *tax only* approach. However, the *permits & tax* strategy yields a better situation in terms of GDP, sectoral impacts and balance of trade. Furthermore, the carbon tax it imposes is reduced compared to the *tax only* strategy, and its implementation should thus face less political opposition. From this point of view, Switzerland should consider the combining of a 'low' national carbon tax with the participation in international schemes to curb CO₂ emissions. Using a different modelling approach, Bahn *et al.* (1998a) were formulating a similar policy recommendation.

GEM-E3 Switzerland is a stand-alone model. However, GEM-E3 exists in a European version describing the 15 countries of the European Union. The integration of the Swiss model with this European version shall be realised within the new European Research Project ENG2-CT1999-00002 *TCH-GEM-E3*. It will require in particular extensive foreign trade data between Switzerland, the European Union and the 'Rest of the World'. This extended European version (Switzerland + 15 EU countries) of GEM-E3 shall be used by PSI to conduct new policy analyses for Switzerland, such as the study of impacts on Switzerland of European energy and environmental policies and the evaluation of potential gains for policy co-ordination.

1. Introduction

Global climate changes may be one of the key environmental issue facing humanity in the next century. Recognising the threat of drastic climate changes, the United Nations Framework Convention on Climate Change (UNFCCC—United Nations, 1992) has called for the “*stabilisation of greenhouse gas*” (GHG) “*concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*”. A first step toward that end was decided in 1997. The Kyoto Protocol to the UNFCCC (United Nations, 1997) sets GHG emission reduction targets for the so-called UNFCCC Annexe I Parties.

To comply with the Kyoto emission reduction requirements, Annexe I Parties decision makers may use several policy options, see for instance Eberle and Bahn (1999), such as market-based (economic) instruments. Such instruments may be implemented on a national basis (e.g., national taxes on GHG emissions) or on an international one (e.g., international trade of GHG emission permits). The Kyoto Protocol has in particular allowed the trade of emission permits, among Annexe I Parties through International Emissions Trading and Joint Implementation schemes, and between Annexe I and non-Annexe I Parties through the Clean Development Mechanism. These latter instruments are often referred to as the Kyoto ‘Flexible Mechanisms’.

Various models have been proposed to assess the curbing of GHG emissions using economic instruments. For an illustration purpose only, let us mention: the DICE model of Nordhaus (1994), the GMMT model of Kypreos (1998), the GREEN model of the OECD (1994) and the MERGE model of Manne *et al.* (1995). The GEM-E3 model (Capros *et al.*, 1997) enables also one to analyse the control of GHG emissions and the internalisation of environmental externalities through economic instruments.

GEM-E3 is an applied general equilibrium model that analyses the macro-economy and its interaction with the energy system and the environment. It follows a computable general equilibrium approach in the sense that it computes the equilibrium prices of goods, services, capital and labour that simultaneously clear all markets under the Walras Law (Walras, 1954). Interactions among the economy, energy system and environment are evaluated through the balancing of energy supply and demand, atmospheric emissions and pollution control, together with the fulfilment of overall equilibrium conditions. The curbing of in particular CO₂ emissions is obtained through taxation and/or tradable emission permits.

This report describes the implementation and application of GEM-E3 for Switzerland. This work was carried within the European Research Project No. JOS3-CT97-0017 *GEM-E3-ELITE*, funded by the European Commission (DGXII), that took place from February 1998 to July 1999. It was under the supervision of Socrates Kypreos and was partially funded by the Swiss Federal Office for Education and Science (*Contract Number 97.0475*).

The implementation for Switzerland of the GEM-E3 model has required the development of a Swiss database for each of GEM-E3 modules (economic module and environmental module). The GEM-E3 economic database consists mostly of a Social Accounting Matrix (SAM). A ‘GEM-E3 compatible’ SAM for Switzerland has

been designed by C. Frei (see Appendix 3) from an existing Swiss SAM (Guillet and Antille, 1998). The Swiss environmental database consists mainly of an Energy Balance Table and of an Emission Coefficients Table. They have been designed using national and international official statistics, and know-how of the PSI GaBE Project.

Using GEM-E3 Switzerland, two strategies to reduce the Swiss CO₂ emissions by 10% by 2010 have been evaluated: a carbon tax and the combining of a carbon tax with the buying of CO₂ emission permits. In the first strategy, Switzerland uses the tax revenue to reduce social security charges. In the second strategy, Switzerland imposes a lower carbon tax than in the first case, and uses part of the tax revenue to acquire emission permits on an international market. The remaining of the tax revenue is then used to reduce social security charges as in the first strategy. Besides the computing of CO₂ emissions and marginal control costs, consequences on economic growth, employment, sectoral production and balance of trade have in particular been assessed for both strategies.

The report is organised as follows. Section 2 gives an overview of the GEM-E3 model. Section 3 describes the Swiss database. Finally, Section 4 reports on the case studies.

2. Overview of GEM-E3

GEM-E3 is a computable general equilibrium model that has been developed, under the auspices of the European Commission (DGXII), by a consortium of European universities and research institutes, see Capros *et al.* (1995, 1997). This section aims at providing the reader with a brief overview of the standard version of the model that has been used for Switzerland. Section 2.1 gives the model's nomenclature. Section 2.2 explicates the model's specifications without using mathematics. For a mathematical presentation of the model's equations, the reader is kindly referred to Capros *et al.* (1997). Finally, section 2.3 describes the particularities of GEM-E3 Switzerland.

2.1 GEM-E3 nomenclature

Depending on its geographic coverage, GEM-E3 exists in several versions: a single country version, a European version with the 15 EU countries and a world version with 18 world regions.

GEM-E3 considers 4 economic agents: producers (firms), consumers (households), government and foreign sector.

Production uses two primary production factors (capital and labour) and is distinguished among 18 sectors:

- agriculture,
- 4 energy branches (coal, oil, gas and electricity),
- 8 industrial branches (ferrous / non-ferrous & metals, chemical products, other energy-intensive products, electrical goods, transport equipment, other equipment goods, consumer goods and building & construction),
- transports, and
- 4 services (telecommunication services, services of credit & insurance, other market services and non-market services).

A representative household consumes 13 consumption categories:

- 2 durable goods (heating & cooking appliances and transport equipment), and
- 11 non-durable goods and services (food / beverages & tobacco, clothing & footwear, housing & water, fuels & power, housing furniture & operation, medical care & health expenses, operation of transport equipment, purchased transport, telecommunication services, recreation / entertainment & culture and other services).

GEM-E3 considers several government revenue and income flow categories:

- direct, indirect and VAT taxation,
- energy and environmental taxation,

- import duties and foreign sector transfers,
- revenues from governmental firms,
- social security and benefits, and
- subsidies.

GEM-E3 computes the emissions of 5 primary pollutants:

- carbon dioxide (CO₂) that contributes to the greenhouse effect increase,
- nitrogen oxides (NO_x) and sulphur dioxide (SO₂) that trigger acid depositions, and
- non-methane volatile organic compounds (NMVOCs) and particulates (PM-10) that contribute to local air pollution.

GEM-E3 is a dynamic, recursive over time, model, involving backward looking expectations. It is solved period per period and follows a time-forward path.

2.2 GEM-E3 specifications

GEM-E3 is composed of two modules (economic and environmental). Each module is briefly described below.

2.2.1 Economic module

The core economic module follows the tradition of the World Bank models, see for instance De Melo (1988), and is based on a Social Accounting Matrix (SAM).

A SAM gives an overview of the economy at a given period. It is an extended Input-Output table, that is completed by a table of income flows and transfers among agents, see Figure 1, page 11. It ensures in particular the balancing of economic flows, since expenditures (sum by columns) are set to be equal to revenues (sum by rows).

In GEM-E3, these flows take place among the 18 production sectors, the two primary production factors (capital and labour) and the 4 economic agents (firms, households, government and foreign sector). Firms produce commodities for intermediate and final consumption, and for investments and stocks. The primary factors they use are rewarded from sectoral value added. These factors belong to all agents that receive an income from the factors rewarding. There are also transactions among agents such as taxes, subsidies and transfers. Beside these transactions, agents use also their revenues for consumption and investments (savings). They may have a deficit or surplus (non-zero difference between spending and earning), but the sum of these differences over the agents is set to zero, in accordance with the Walras Law.

The definition of economic agents and their transactions follows thus in GEM-E3 the framework of a SAM. Here follow some details about their behaviour.

	Sectors	Factors	Agents	Investments & stocks	Total expenditures
Sectors	<i>intermediate consumption</i>	0	<i>final consumption</i>	<i>investments & stocks' variation</i>	<i>total demand of commodities</i>
Factors	<i>factors rewarding</i>	0	<i>income transfers from foreign</i>	0	<i>total revenues of factors</i>
Agents	<i>taxes & subsidies</i>	<i>factor payments to agents</i>	<i>income transfers among agents</i>	0	<i>total revenues of agents</i>
Savings	0	0	<i>investments & stocks' variation</i>	0	
Total revenues	<i>total supply of commodities</i>	<i>total payments of factors</i>	<i>total spending of agents</i>	0	
Deficit / surplus	0	0	<i>agents' lending capacity</i>	0	

Figure 1. Social Accounting Matrix

Producers correspond to sectors (columns) of the Input-Output table. Assuming perfect competition, a single representative firm operates in each of the 18 sectors, and produces a single uniform commodity (good or service) using a constant return of scale production technology (represented by the physical capital stock). More precisely, the sectoral firm produces its commodity using two primary factors (capital and labour) as well as energy and materials that correspond to the firm's intermediate consumption following the sectoral classification. Substitution possibilities among production factors depend on the relative factors' prices, following a nested constant elasticity of substitution (CES) production function, see Figure 2, page 12. Under short-term profit maximisation, the firm decides the level to which it supplies its commodity to the market, given its selling price and the prices of the production factors. The firm cannot change its capital stock within the current period. It can only do so the following period, by investing in the current one. Notice that investment permits not only to expend the firm's productive capacity, but also to replace obsolete capital stock. Given that the firm has a fixed capital stock within the current period, the supply curve of the commodity it produces shows a decreasing return of scale.

Consumers are described by one representative household. Its behaviour is modelled through a two-stage decision tree. At the first level, the representative household allocates its lifetime wealth endowment between present and future consumption of commodities and leisure. This consumption/leisure choice is modelled through the maximising of an inter-temporal (Cobb-Douglas) utility function subject to an inter-temporal budget constraint imposing the spending of all incomes. Under restrictive assumptions such as myopic expectations about the future, one derives the steady-state formulation of this allocation problem. The latter is then formulated under this form in the model. In other world, under in particular myopic expectations, the household

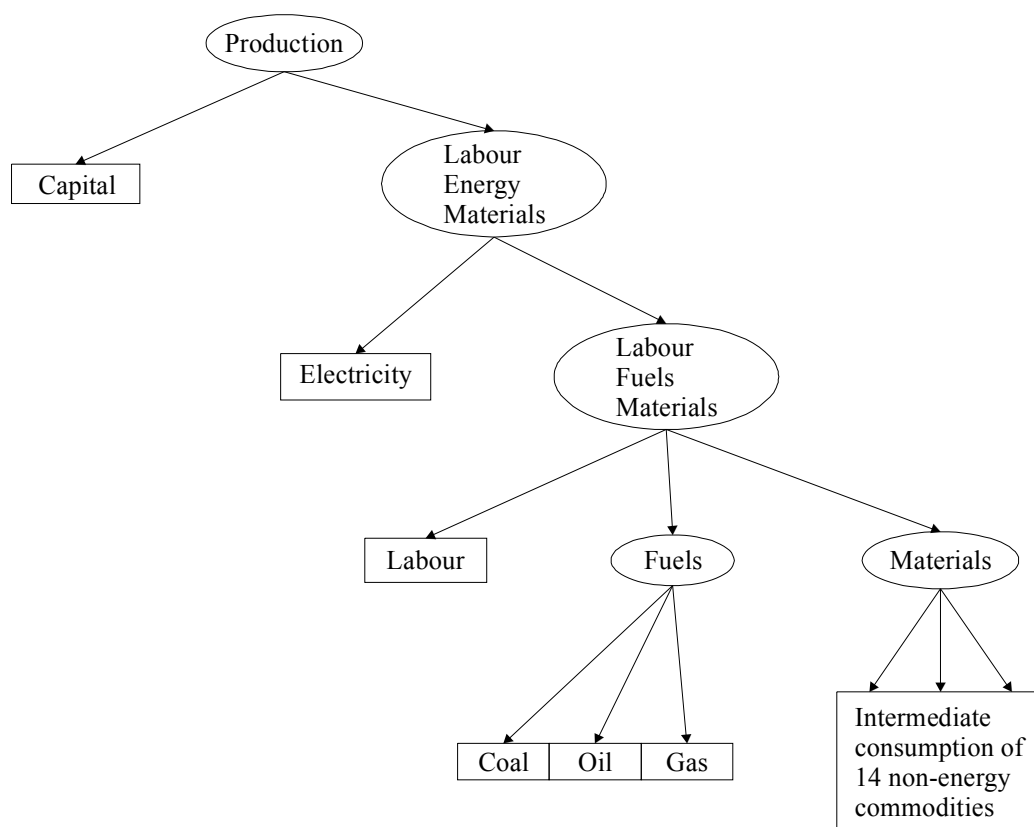


Figure 2. Nested domestic production scheme

gives up a certain amount of leisure time in order to acquire a desired amount of income. Notice that the labour supply (in time unit) is then given by the remaining time resources, namely the total (fixed) time resources minus the leisure demand (in time unit). Disposable income is then allocated between consumption and savings. The latter correspond to investments in dwellings and the buying of monetary assets. At the second level of the decision tree, total consumption of commodities is allocated among 2 durable goods and 11 non-durable goods & services. Notice also that the consumption of some non-durable goods, such as fuels and power, is linked to the stock of durable goods. The household's allocation problem is schematised in Figure 3, page 13.

Government behaviour is mainly exogenous. Government revenues are distinguished among several categories, following the framework of the SAM, see Section 2.1. These revenues are mostly determined by applying exogenous rates. As far as government spending is concerned, government spends for public consumption (of goods and services) and for public investment. Total public consumption and investment are exogenous. Government transfers also social benefits to the other economic agents.

Foreign sector behaviour is left exogenous in the single country version of GEM-E3. Imports demanded by the foreign sector depend on export prices set up by the country. Exports from the foreign sector to the country are sold at an exogenous price. Total domestic demand corresponds to demand of goods and services by producers,

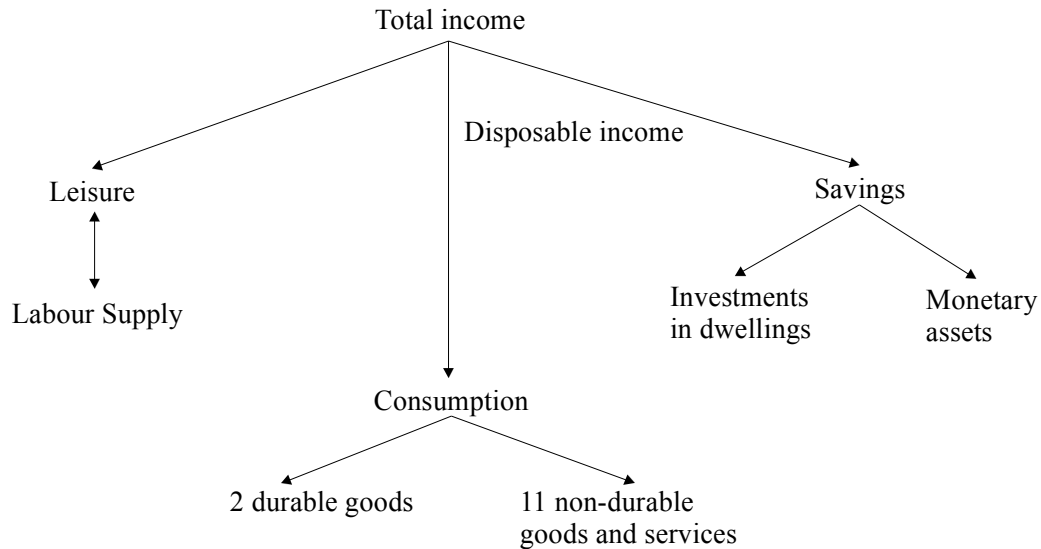


Figure 3. Households' allocation scheme

consumers and the government for consumption and investment. It is allocated between domestic and imported commodities following the Armington (1969) specification. That is, national economic agents demand, under cost-minimisation, a composite product formed by domestically produced and imported commodities, that are considered as imperfect substitutes. Moreover, domestic production is addressed to two different markets: the national and the foreign ones. It is assumed that domestic producers can apply, under profit-maximisation, two different pricing schemes for these two markets.

When the economy is in equilibrium, supply equals demand in all markets, and prices are such that economic agents optimise their behaviour (producers achieve maximum profits and consumers fully use their budget). Moreover, the sum of agents' deficit or surplus is equal to zero in accordance with the Walras Law. When the economy is not in an equilibrium point, this Law may not be satisfied. To reach an equilibrium that satisfies the Walras Law, GEM-E3 uses an iterative process called macro-closure. Since the equilibrium depends only on relative prices (called 'numeraire'), GEM-E3 has exactly one degree of freedom, and a particular macro-closure rule must be chosen. GEM-E3 usually uses the 'Investments-Savings' (IS) global closure that imposes a strict equality between investments and savings. Such a macro-closure is rather traditional in computable general equilibrium models.

2.2.2 Environmental module

The second module that composes GEM-E3 is the environmental module. It considers atmospheric emissions of 5 primary pollutants, see Section 2.1, related to energy consumption. Concerning greenhouse gases, the environmental module evaluates the energy-related emissions of CO₂, the main contributor to the additional climate forcing (IPCC, 1996a). More precisely, CO₂ emissions are computed in linear relation (using exogenous emission factors) to the use of fossil fuels.

GEM-E3 considers 3 types of emission control instruments: emission standards, emission taxes and tradable emission permits.

- **Standards** can be imposed at the level of durable goods (e.g., cars) or at the level of sectors. They may also take the form of global constraints on emissions. The associated dual variable (endogenously computed by GEM-E3) acts then as an emission tax.
- **Taxes** can also be imposed on energy. This shall trigger as well emission reductions. Notice further that taxes generate an additional revenue for the government. GEM-E3 considers several ways to use this revenue: e.g., to reduce the public deficit, or to reduce the social security rates of employers.
- A **market of emission permits** can be designed following several alternatives: initial endowments among polluters of emission permits may be given for free following a given allocation rule (e.g., ‘grand-fathering’ principle) or may be auctioned. In the latter case, an additional revenue for the government is also generated, that may be used as explained above for the emission tax revenue.

For the producers and the consumers, the user cost of energy is increased by the application of these emission control instruments. This cost intervenes in the producers’ selection of production factors and in the consumers’ decision about consumption categories and levels. From this perspective, CO₂ emissions, in particular, can be reduced through production restructuring (substitution among fuels, and between energy and non-energy inputs) and through demand restructuring.

2.3 GEM-E3 Switzerland

GEM-E3 Switzerland is based on the standard version of the GEM-E3 model. This means in particular that perfect competition is assumed to prevail in all markets (labour market, markets for goods and services) and that the macro-closure rule it uses is the IS-closure. GEM-E3 Switzerland has furthermore the following characteristics.

It corresponds to the single country version of GEM-E3. This implies that the foreign sector represents all other world countries. That imposes limitations, especially when analysing foreign trade. These limitations shall be addressed during the new European Research Project *TCH-GEM-E3*, see Section 5.3.

It uses as a base year 1990 and projects forward to the year 2010 in steps of 5 years (1990, 1995, 2000, 2005 and 2010).

In the baseline scenario, see Section 4, technical progress (related to capital, labour, energy and materials use) and economic growth of the foreign sector (‘Rest of the World’—ROW) are calibrated to achieve a given target for GDP growth. In subsequent policy scenarios, where CO₂ emissions are reduced, technical progress and economic growth of ROW remain unchanged, and the GDP growth rate is endogenously computed.

3. GEM-E3 Switzerland database

Following the two modules of GEM-E3, the Swiss database is composed of two parts: an economic database and an environmental database. Each one is briefly described below.

3.1 Economic database

The Swiss economic database consists mostly of a Social Accounting Matrix (SAM). The latter has been constructed from a Swiss SAM developed for the year 1990 by Guillet and Antille (1998) of the Laboratory of Applied Economics (LEA—University of Geneva). This SAM is already calibrated, but its format is not consistent with the one of GEM-E3. It uses the NGAE nomenclature with 37 sectors and 8 consumption categories, whereas GEM-E3 uses the NACE nomenclature (18 sectors and 13 consumption categories). The main development work has thus consisted in transforming this SAM in the requested nomenclature. Sectors and consumption categories had to be further disaggregated and partially re-aggregated. This disaggregation step has required many additional data. Among other tasks were an estimation of the investment matrix, the sectoral disaggregation of the value added data and the elaboration of the transfer matrix. These steps are shortly explained below and detailed in Appendix 3.

In the LEA's SAM, the **Input-Output (I/O) Matrix** has a 37x37 format. To make it consistent with the GEM-E3 format, several steps were necessary. It was first expanded to a 39x39 format by disaggregation of the 'electricity-gas-water' aggregate, using statistics provided by the Institute for Business Cycle Research (KOF). The resulting 39 sectors were consistent with the 18 GEM-E3 sectors with only two exceptions that had to be split and re-affected following a simple translation key, due to the lack of better data. The subsequent re-aggregation step corresponds therefore to a double linear transformation of the 39x39 into a 18x18 structure.

The 18x13 **Consumption Matrix** was directly obtained by aggregation of original statistical data (a survey on household budgets for 1990 on 280 categories) into the 13 GEM-E3 categories. Price corrections had to be performed to transform values in demand market prices into values in supply market prices, by deduction of commercialisation fees according to LEA's data. The sectoral dis- and re-aggregation were done consistently with what has been done for the I/O Matrix.

The LEA's SAM does not contain an **Investment Matrix** as such, but rather 12 values corresponding to investments of 6 institutional sectors into an equipment investment good and a construction investment good. An 18x18 Investment Matrix has been estimated using partial data from KOF, the Swiss Federal Statistical Office (SFSO) and LEA, and by making some strong assumptions concerning the homogeneity of the investment good's structure.

The **Revenues from Sectors Matrix** has been elaborated from the LEA's SAM and from data compiled specially by SFSO.

The **Transfers between Sectors Matrix** has been drawn from the Swiss National Accounts.

The complete Swiss SAM is given in the Appendix 1.1 and 1.2.

3.2 Environmental database

The Swiss environmental database consists mainly of an Energy Balance Table and of an Emission Coefficients Table.

The **Energy Balance Table** has been designed following the Swiss Federal Office of Energy (1991) and the IEA/OECD (1993). This table is given in Appendix 2.1.

The **Emission Coefficients Table** has been built following the Swiss Agency for the Environment, Forests and Landscape (1995) and using know-how of the PSI GaBE Project¹. This table is given in Appendix 2.2.

These two tables enable one to compute, for the 18 production sectors and for the consumers, exogenous percentages of fossil fuels consumption that generates emissions, as well as associated (exogenous) emission coefficient factors.

¹ Information on the PSI GaBE Project can be found on the internet at the following address: “<http://pss100.psi.ch/~shirsch/gabe/gabehome.html>”.

4. CO₂ reduction analyses with GEM-E3 Switzerland

The purpose of these analyses is to evaluate economic consequences for Switzerland of policies to reduce its CO₂ emissions by 10% from the 1990 level by 2010. It should be noted that this target is more stringent than the one (8% reduction by 2008-2012) agreed by Switzerland in the Kyoto Protocol. But it corresponds to the reduction target approved by the Swiss Federal Assembly in October 1999.

Two scenarios are thus considered:

- a **baseline scenario**, where CO₂ emissions are not limited, and
- a 10% CO₂ emission **reduction scenario**, where the abatement target is based on the 1990 emission level and is to be reached by 2010. This reduction is supposed to be achieved linearly, assuming that a 5% reduction target is also imposed by 2005.

For each scenario, two variants are considered related to technical progress (associated with capital, labour, energy and materials use) and economic growth of the foreign sector (ROW):

- a **low growth variant**, and
- a **high growth variant**.

The framework of the baseline scenario is then as follows:

	Low growth	High growth
Population	+5.4% (from 7.1 to 7.4 millions) by 2010	+5.4% (from 7.1 to 7.4 millions) by 2010
GDP	+1% / year, in real terms	+2% / year, in real terms
Fossil fuels prices	+1% / year	+1% / year
CO ₂ emissions	stabilised (at 45.1 million tons) by 2010	+2% (up to 46 million tons) by 2010

Table 1. *Baseline scenario framework, between 1995 and 2010*

The assumed population development corresponds to the scenario ‘A-00-95 Trend’ of the Swiss Federal Statistical Office (1999). It should be recalled from Section 2.3 that the targeted GDP growth rates are achieved by adjusting the assumed technical progress ratios and economic growth of the ROW. The stabilisation of CO₂ emissions in the *low growth* variant is mainly due to the assumed technical progress (especially related to energy use) and to the assumed increase in fossil fuels prices. It should be noted that taxes on non-renewable energy carriers recently approved by the Swiss Federal Assembly² are not considered in these simulations. In the *high growth* variant, CO₂ emissions increase by only 2 per cent relative to the *low growth* variant, whereas GDP increases by around 16%. This is consistent with the historical trend, observed in

² The Federal Assembly has approved in October 1999 a renewable energy encouragement tax of 0.3 Swiss cents per kilowatt-hour and a neutral excise tax of 2 Swiss cents per kilowatt-hour. A popular vote must also be held before these taxes can be levied.

industrialised countries, of de-coupling between GDP growth and energy consumption (and hence CO₂ emissions).

Along with the *reduction* scenario, two cases are considered that correspond to two strategies to reduce the Swiss CO₂ emissions:

- the imposition of a carbon tax (**‘tax only’ strategy**). In this first strategy, Switzerland imposes the necessary carbon tax to achieve the reduction target, and uses the tax revenue to reduce social security charges. And,
- the combining of a carbon tax with the buying of CO₂ emission permits on an international market (**‘permits & tax’ strategy**). In this second strategy, Switzerland imposes a lower carbon tax than in the first strategy. Consequently, the CO₂ reduction achieved is not enough to fulfil the reduction target. To do so, Switzerland uses part of the tax revenue to acquire emission permits on an international market. And it uses the remaining of the tax revenue to reduce social security charges as in the first strategy.

4.1 Reduction through a carbon tax

In this section, the *tax only* strategy is analysed under two variants for economic development: *low growth* and *high growth*.

4.1.1 CO₂ emissions and tax level

GEM-E3 Switzerland ensures that the desired CO₂ reduction targets are fulfilled, that is: starting from 45 million tons in 2000, 42.8 million tons in 2005 and 40.5 million tons in 2010. These targets are implemented in the model as global constraints on CO₂ emissions. The associated dual variables computed by the model correspond to a carbon tax, whose levels are as follows.

	2005	2010
Low growth	35	83
High growth	45	103

Table 2. CO₂ tax rate (in Swiss francs 1990 per ton CO₂) to reach a 5% reduction by 2005 and a 10% reduction by 2010, in the *tax only* strategy

To reduce by 10% CO₂ emissions by means of a carbon tax, the maximum taxation level computed by GEM-E3 Switzerland, in the *high growth* variant, is thus 103 CHF per ton CO₂. This level is similar to one of the taxation levels envisioned by the Swiss Federal Council (1997): 60 CHF per ton CO₂, plus in particular an energy tax on gasoline, diesel and jet fuel equivalent to 42 CHF per ton CO₂; noticing that the baseline projection of the Federal Council supposes a stabilisation of the Swiss CO₂ emissions, as in the *low growth* variant. Notice also that the over-proportional growth of the tax with percentage of emission reduction reflects the increasing marginal cost of the reduction measures.

The carbon tax revenue is then used to reduce the social security rate of employers, so as to trigger a so-called ‘double dividend’; see below, where are presented consequences of the taxation scheme on selected macro-economic indicators.

4.1.2 Gross Domestic Product

The imposition of the carbon tax has a negligible impact on the Swiss GDP, see below.

	Low growth		High growth	
	2005	2010	2005	2010
In million CHF 1990	0.7	-55.4	4.1	-42.1
In percentage	0.00%	-0.01%	0.00%	-0.01%

Table 3. Variations of the GDP (in producer prices) relative to the baseline in the *tax only* strategy

For both variants, two opposite trends are observed.

- On the one hand, GDP is driven upward by an increase in consumption and a decrease in imports (of fossil fuels, in particular). Indeed, the taxation scheme used to curb CO₂ emissions yields an increase in energy prices (due directly to the carbon tax) and a decrease in labour costs (due to the recycling of the tax revenue to reduce the social security rate of employers). Consequently, producers react by changing their production structure, and demand less energy and more labour than in the *baseline* scenario. The first modification (less energy demanded) yields the above mentioned decrease in imports, see also Section 4.1.5. The second modification (more labour demanded), within a competitive labour market as modelled in GEM-E3 Switzerland, triggers an increase in real wages. This in turn yields an increase in consumption.
- On the other hand, GDP is driven downward by a decrease in investments and in exports. As mentioned, the CO₂ emission taxation scheme introduces changes in the relative prices of the production factors. Indeed, labour becomes more competitive than it is in the *baseline* scenario, compared to energy but also to capital. In the production structures, a fraction of capital is thus substituted by labour. The decreasing capital demand implies, compared to the *baseline* scenario, a lower rate of return for capital and consequently a decrease in total investment. The analysis concerning exports is given in Section 4.1.5.

Overall, the first trend (increase in consumption and a decrease in imports) is stronger in 2005, the second (decrease in investments and in exports) in 2010.

4.1.3 Employment

When recycling the carbon tax revenue to reduce the social security rate of employers, the impact on employment is slightly positive, see below.

	Low growth		High growth	
	2005	2010	2005	2010
In thousands	4.9	11.1	6.3	13.4
In percentage	0.12%	0.26%	0.15%	0.32%

Table 4. Variations of the employment level relative to the baseline in the *tax only* strategy

Notice that the positive effect on employment is higher in the *high growth* variant, when the carbon tax revenue is higher. It should also be noted that not all sectors are benefiting, in terms of employment, from this taxation scheme. Indeed, in all variants, employment is decreasing in the energy production sectors (especially in the ‘Crude Oil and Oil Products’ sector and in the ‘Natural Gas’ sector).

This CO₂ emission taxation scheme is thus leading to an overall ‘double dividend’ for Switzerland, namely a reduction of its CO₂ emissions (environmental benefit) and an increase of its overall employment level (societal benefit). As mentioned in Section 4.1.2, this taxation scheme is also triggering a reduction in the fossil fuels imports, that enables Switzerland to reduce its dependency on foreign energy resources.

This double dividend results from an increase in energy prices (due to the carbon tax) coupled with a decrease in labour costs (due to the tax revenue recycling). These changes, in the relative prices of the production factors, trigger then substitutions in the production structures, away from energy (and also from capital, as mentioned in Section 4.1.2) and in favour of labour. Less (fossil) energy consumed implies fewer CO₂ emissions. More labour demanded by producers yields both an increase in real wages and in employment.

The increase in real wages relative to the one in employment depends on the ‘bargaining power’ of the already employed people. The more this power, the higher the gain in real wages, and the lower the gain in employment. In other words, the effect on employment of the CO₂ emission taxation scheme considered depends on the structure of the labour market regime. The rigidity vs. flexibility of the labour supply is estimated in GEM-E3 through the real wage rate elasticity of labour supply. This labour supply elasticity is calibrated for the base year (1990) and endogenously evaluated by GEM-E3 thereafter.

In GEM-E3 Switzerland, the 1990 labour supply elasticity is calibrated to the European Union average level. As a sensitivity analysis, one may calibrate this elasticity to a 50% lower value to simulate a more rigid labour supply. This case is labelled thereafter ‘more rigid’. For the *high growth* variant, Table 5, page 21, compares this new labour market regime to the previous ‘standard’ one (labelled ‘EU average’).

Table 5 shows as expected that under a more rigid labour market regime, gains in employment are lower and gains in real wages higher than under a more flexible regime. Furthermore, in the *more rigid* variant, GDP losses are more important. Indeed, a more rigid labour supply yields a stronger consumers prices increase and

	EU average		More rigid	
	2005	2010	2005	2010
GDP	0.00%	-0.01%	-0.02%	-0.04%
Employment	0.15%	0.32%	0.12%	0.26%
Real wage	0.31%	0.61%	0.37%	0.72%

Table 5. Variations in percentage of the GDP, employment and real wage levels relative to the baseline, in the *tax only* strategy, under two labour market regimes

further competitiveness losses (due to higher wages), that in turn lead to a more important degradation of the production level.

4.1.4 Sectoral impacts

The impact of the CO₂ emission taxation scheme on the production (in real terms) of the 18 GEM-E3 sectors is given in Table 6, page 22.

The taxation scheme is significantly affecting the energy production sectors, especially the ‘Crude Oil and Oil Products’ sector and the ‘Natural Gas’ sector. The introduction of the carbon tax is indeed fostering energy conservation measures and substitutions away from (fossil fuels) energy in the economy, that lead to a demand reduction in these two energy production sectors. This reduction trend is stronger in the *high growth* variant, where the carbon tax is higher. Notice that the ‘Coal’ sector is of no importance in Switzerland. Notice further that, in the *baseline* scenario, the production of the ‘Natural Gas’ sector increases more in percentage (by 2010, relative to the 2000 value) than the production of the ‘Crude Oil and Oil Products’ sector. Whereas in the *reduction* scenario, the production of the ‘Natural Gas’ sector decreases less in percentage (again by 2010, relative to the 2000 value) than the production of the ‘Crude Oil and Oil Products’ sector. This holds under both variants (*low growth* and *high growth*).

Impacts on the other sectors are rather limited, under 1% for all variants and time periods. Notice also that all these other sectors have a slight decrease in production, except the services sectors: ‘Telecommunication Services’, ‘Credit and Insurance’, ‘Other Market Services’ and ‘Non Market Services’. Indeed, these services sectors are labour intensive and use rather little energy. They benefit thus fully from the reduction of labour costs (due to the recycling of the carbon tax revenue to reduce the social security rate of employers) and suffer little from the energy costs increase (due to the imposition of the carbon tax).

4.1.5 Foreign trade

It should first be recalled that the current (1999) GEM-E3 Switzerland model is not integrated into the European Union version of GEM-E3. Consequently, all foreign countries are included in a single ‘Rest of the World’ region. Furthermore, it is

	Low growth		High growth	
	2005	2010	2005	2010
Agriculture	-0.01%	-0.03%	-0.01%	-0.01%
Coal	N.A.	N.A.	N.A.	N.A.
Crude oil and oil products	-3.80%	-7.41%	-4.60%	-8.32%
Natural gas	-2.76%	-6.36%	-3.98%	-8.69%
Electricity	-0.14%	-0.38%	-0.21%	-0.53%
Ferrous, non-ferrous ore and metals	-0.10%	-0.20%	-0.10%	-0.16%
Chemical products	-0.12%	-0.25%	-0.12%	-0.22%
Other energy intensive industries	-0.28%	-0.62%	-0.35%	-0.69%
Electrical goods	-0.08%	-0.15%	-0.07%	-0.11%
Transport equipment	-0.10%	-0.19%	-0.10%	-0.17%
Other equipment goods industries	-0.09%	-0.17%	-0.09%	-0.14%
Consumer goods industries	-0.06%	-0.13%	-0.07%	-0.13%
Building and construction	-0.01%	-0.03%	-0.01%	-0.02%
Telecommunication services	0.06%	0.13%	0.09%	0.20%
Transports	-0.35%	-0.76%	-0.42%	-0.81%
Credit and insurance	0.00%	0.00%	0.01%	0.02%
Other market services	0.02%	0.03%	0.02%	0.06%
Non market services	0.06%	0.13%	0.08%	0.17%

Table 6. Variations in percentage of the production per sector (in real terms) relative to the baseline in the *tax only* strategy

assumed that this region is not curbing its CO₂ emissions. The assumption, imposed by the current limitations of GEM-E3 Switzerland, that Switzerland is reducing unilaterally its CO₂ emissions is not a realistic one. Indeed, if the Kyoto Protocol is to be followed, the so-called UNFCCC Annexe I Parties (38 industrialised countries and economies in transition) are due to reduce their (in particular) CO₂ emissions by an average 5.2% by 2008-2012 from the 1990 levels. With these caveats, impacts of the CO₂ emission taxation scheme on foreign trade (in real terms) are given in Table 7, page 23.

Under all variants and time periods, the Swiss trade balance is deteriorating, but especially in the *low growth* variant. This can be explained by the following two trends.

	Low growth		High growth	
	2005	2010	2005	2010
Δ Exports	-0.20%	-0.40%	-0.21%	-0.35%
Δ Imports	-0.15%	-0.30%	-0.19%	-0.35%
Δ Trade balance	-0.40%	-0.69%	-0.25%	-0.36%

Table 7. Variations in percentage of exports, imports and trade balance (Δ exports - Δ imports), relative to the baseline, in the *tax only* strategy

- On the one hand, Swiss exports are decreasing. This results from several direct and indirect effects. Producers are responsible for only a fraction of the total CO₂ emissions, the remaining comes from consumers. Although they contribute to only a fraction of the total tax revenue, producers receive it entirely as a reduction of their social security rate. A first direct effect that increases the Swiss competitiveness corresponds thus to a transfer (subsidy) from consumers to producers. There is also an opposite indirect effect. As mentioned in Section 4.1.3, the CO₂ emission taxation scheme increases both the employment level and the real wages level. This corresponds then to a transfer from producers to consumers. From the perspective of the production factors costs, as already mentioned, they evolve in opposite directions: energy costs increase (due to the carbon tax) and labour costs decrease (due to the revenue recycling scheme). This has opposite effects on the Swiss competitiveness. Overall, compared to the baseline, there are competitiveness losses that lead to a reduction of the Swiss exports.
- On the other hand, Swiss imports are also decreasing. This is mainly due to the reduction of fossil fuels imports. Indeed, as already mentioned, the imposition of the carbon tax is fostering energy conservation measures and substitutions away from (fossil fuels) energy in the economy.

Overall, the first trend (reduction of exports) dominates the second one (reduction of imports) and yields a deterioration of the Swiss balance of trade.

4.2 Reduction through the combining of a carbon tax and emission permits

In the *tax only* strategy analysed in the previous Section 4.1, the carbon tax revenue is recycled domestically to reduce social security charges. This new section compares the *tax only* strategy with the *permits & tax* strategy for the *high growth* variant only. In this second strategy, part of the carbon tax revenue is used to acquire CO₂ emission permits on an international market.

The Kyoto Protocol has indeed allowed the trade of emission permits, among Annexe I Parties through International Emissions Trading and Joint Implementation schemes, and between Annexe I and non-Annexe I Parties through the Clean Development Mechanism. These schemes are often referred to as the Kyoto ‘Flexible Mechanisms’. The incentive for using them comes from important variations that exist among national marginal costs for CO₂ emission reduction, see for example the IPCC

(1996b), and corresponds to the possibility to curb emissions in countries where it is relatively cheaper to do so.

Compared to many other countries, Switzerland has relatively high marginal CO₂ abatement costs; see for instance Bahn *et al.* (1998b) or Kram and Hill (1996). It makes thus economic sense for Switzerland to fulfil part of its CO₂ reduction target through the buying abroad of emission permits.

Within the given 10% reduction target, up to which level should Swiss CO₂ emissions be reduced depends on the cost of abatement measures in Switzerland relative to the international price of emission permits. Economic theory says that CO₂ emissions should be curbed in Switzerland up to the point where Swiss marginal abatement costs equal international prices of CO₂ emission permits. In other words, Swiss emissions should be reduced as long as additional domestic abatement measures are cheaper than the buying abroad of emission permits. Given the structure of the Swiss abatement costs compared to the one of many other countries, it is likely that a significant part of the 10% reduction target could be achieved through the buying of emission permits on an international market.

Besides these direct economic considerations, other aspects should also be taken into account. One aspect relates for instance to indirect economic effects. Implementing in Switzerland the CO₂ emission reduction shall be an important factor for the development by Swiss industries of innovative ways to use energy more efficiently and to control CO₂ emissions. By contrast, transferring the bulk of the emission reduction to other countries (through the buying of emission permits) should reduce technological innovation of Swiss industries in the pollution control domain and may affect in the long run their international competitiveness. Another aspect relates to the political dimension of the issue. Several countries are indeed calling for limitations ('ceilings') to the use of the Kyoto Flexible Mechanisms. In particular, the European Union is proposing limitations to the buying and selling of emission permits, such that at least 50% of the emission reduction is achieved via domestic actions.

The *permits & tax* strategy takes place in this 'ceilings' context, assuming that 50% of the total CO₂ emission reduction (from the baseline) must be—and is—achieved domestically. This lower target (compared to the initial 10% reduction one) is reached through the imposing of a carbon tax. It is furthermore assumed that the initial (10%) reduction target is then fulfilled through the buying of emission permits at an exogenous price. One has to take such a (limited) assumption for the international price of CO₂ permits, given that GEM-E3 Switzerland is currently a stand-alone national model where the 'Rest of the World' is exogenously specified. This point is further discussed in Section 4.2.1, below. To buy emission permits, it is assumed that Switzerland uses part of its carbon tax revenue. The remaining of this tax revenue is then used, as in the *tax only* strategy, to reduce the social security rate of employers.

4.2.1 CO₂ emissions, permits and tax

In the *permits & tax* strategy, one supposes that at least 50% of the CO₂ emission abatement (from the baseline), for each period (2005 and 2010) where a reduction is performed, must be achieved domestically. Given the relative high marginal

abatement costs in Switzerland compared to many other Annexe I and non-Annexe I countries, one supposes that it is not economically efficient to perform more reduction (than 50% of the total target) via domestic actions. The CO₂ emission levels that must be reached are thus: starting from 45 million tons in 2000, 44.3 million tons in 2005 and 43.3 million tons in 2010. This reduction is achieved by means of a carbon tax, whose level is as follows:

- 20 Swiss francs 1990 per ton CO₂ in 2005, and
- 42 Swiss francs 1990 per ton CO₂ in 2010.

The carbon tax level is thus reduced by a factor more than 2 compared to the *tax only* strategy. Its imposition should thus face less political opposition.

To fulfil its initial 10% reduction target, Switzerland buys on an international market CO₂ emission permits for a total of 4.3 million tons. It is supposed that the international market price, in 2005 and 2010, for these emission permits is identical to the Swiss carbon tax level.

From a consistency perspective, if the market price of an emission permit would be higher than that, Switzerland would perform more reduction via domestic actions. Furthermore, the assumption regarding the international market price level of CO₂ emission permits is in line with a recent study performed at the Paul Scherrer Institute. Using an optimisation equilibrium world model, Kypreos and Bahn (1999) have simulated the functioning of a world market of CO₂ emission permits, where all Annexe I and non-Annexe I regions would participate. When no restriction ('ceiling') is imposed to the trade of CO₂ emission permits, their market price is evaluated at around 40 Swiss francs 1990 per ton CO₂ by 2010 when the Annexe I regions fulfil their Kyoto target.

If such a world market (or even regional ones) are not established by 2010, Switzerland would have to negotiate bilateral agreements, for example with non-Annexe I countries. In Bahn *et al.* (1999) for instance, a Clean Development Mechanism scheme has been simulated between Switzerland and Colombia with a bottom-up engineering model. This study estimates that Colombia could sell, between 2005 and 2010, around 8 million tons of certified CO₂ emission reductions at about 18 Swiss francs 1990 per ton CO₂. To take such a possibility into consideration, Section 4.2.6 presents a sensitivity analysis performed with a 2 times lower price level for the CO₂ emission permits: 10 Swiss francs 1990 per ton CO₂ in 2005 and 21 in 2010.

The 4.3 million tons CO₂ emission permits bought, in the *permits & tax* strategy, are paid using part of the carbon tax revenue. The remaining of this revenue is then used to reduce the social security rate of employers, so as to trigger a 'double dividend'; see below, where are presented consequences of the taxation scheme on selected macro-economic indicators.

4.2.2 Gross Domestic Product

The new CO₂ emission reduction scheme has again a negligible impact on the Swiss GDP, see below.

	Tax only		Permits & tax	
	2005	2010	2005	2010
In million CHF 1990	4.1	-42.1	0.33	-23.15
In percentage	0.00%	-0.01%	0.00%	-0.01%

Table 8. Variations of the GDP (in producer prices) relative to the baseline in the *tax only* and *permits & tax* strategies, under the *high growth* variant

For both strategies, two opposite trends are observed.

- On the one hand, GDP is driven upward by an increase in consumption and a decrease in imports (of fossil fuels, in particular); see Section 4.1.2 for a more precise description of the factors involved.
- On the other hand, GDP is driven downward by a decrease in investments and in exports; see again Section 4.1.2 for a more detailed explanation.

Overall, the first trend is stronger in 2005, the second in 2010. In the *permits & tax* strategy, these trends are weaker than in the *tax only* strategy. Indeed, the total abatement cost (reduction of Swiss emissions and buying of emission permits) is reduced in the former strategy. One expects thus this strategy to have an overall lower economic impact than the *tax only* strategy. In particular, Table 8 shows that the *permits & tax* scheme is overall a slightly better approach than the *tax only* strategy in terms of GDP.

4.2.3 Employment

In the *permits & tax* strategy, only part of the carbon tax revenue is recycled domestically to reduce the social security rate of employers. The impact on employment is however still slightly positive, as shown below.

	Tax only		Permits & tax	
	2005	2010	2005	2010
In thousands	6.3	13.4	2.8	5.4
In percentage	0.15%	0.32%	0.07%	0.13%

Table 9. Variations of the employment level relative to the baseline in the *tax only* and *permits & tax* strategies, under the *high growth* variant

It should first be noted that not all sectors are benefiting, in terms of employment, from the *permits & tax* scheme. Indeed, as in the *tax only* strategy, employment is decreasing in the energy production sectors (especially in the ‘Crude Oil and Oil Products’ sector and in the ‘Natural Gas’ sector).

The *permits & tax* strategy leads thus also to an overall ‘double dividend’ for Switzerland, that is a reduction of its CO₂ emissions (environmental benefit) and an

increase of its overall employment level (societal benefit). As mentioned in Section 4.2.2, this scheme triggers also a decrease in the fossil fuels imports, that enables Switzerland to reduce its dependency on foreign energy resources.

As in the *tax only* strategy, the double dividend results from an increase in energy prices (due to the carbon tax) coupled with a decrease in labour costs (due to the domestic recycling of part of the tax revenue). Compared to this strategy, energy prices increase less in the *permits & tax* scheme, since the carbon tax is imposed at a lower level, see Section 4.2.1. Furthermore, the reduction of the labour costs is also less in the *permits & tax* scheme, since the carbon tax revenue is lower than in the *tax only* strategy and since only part of this revenue is recycled domestically. Fewer relative differences in the prices of the production factors imply fewer substitutions, in the production structures, in particular away from energy and in favour of labour. Consequently, as quantified in Table 9, the *permits & tax* strategy yields a lower employment increase than the *tax only* strategy.

4.2.4 Sectoral impacts

The impact of the *permits & tax* scheme on the production (in real terms) of the 18 GEM-E3 sectors is compared to the one of the *tax only* strategy in Table 10, page 28.

Notice first that impacts on all sectors are rather limited (under 1%), except for the ‘Crude Oil and Oil Products’ sector and the ‘Natural Gas’ sector. On all sectors (except on the ‘Building and Construction’ one), the *permits & tax* strategy produces fewer impacts than the *tax only* strategy. Indeed, as already mentioned, the total abatement cost (reduction of Swiss emissions and buying of emission permits) is lower in the former strategy. Consequently, the fulfilment of the Swiss CO₂ reduction target through the *permits & tax* scheme yields fewer sectoral impacts than the *tax only* strategy. This can be explained by the following two factors.

- On the one hand, the carbon tax levied is lower in the *permits & tax* strategy. Energy prices increase thus less than in the *tax only* scheme. This leads to fewer sectoral impacts (production reduction), especially on the energy production sectors (such as ‘Crude Oil and Oil Products’ and ‘Natural Gas’), but also on all sectors that are more (negatively) affected by energy prices increase than labour costs decrease.
- On the other hand, the carbon tax revenue domestically recycled is lower in the *permits & tax* scheme. Labour costs decrease thus less than in the *tax only* strategy. This leads to fewer sectoral impacts (production increase) on the services sectors that are rather labour intensive.

The ‘Building and Construction’ sector is the only sector on which the impacts produced by the *permits & tax* strategy are higher than the ones of the *tax only* scheme. It is indeed more affected by the relative lower decrease of labour costs than by the relative lower increase of energy costs.

Overall, the *permits & tax* strategy produces thus fewer sectoral impacts than the *tax only* scheme. It is also a more equitable approach, in the sense that it reduces the variance of the sectoral production variations. In other words, the *permits & tax*

	Tax only		Permits & tax	
	2005	2010	2005	2010
Agriculture	-0.01%	-0.01%	-0.01%	-0.01%
Coal	N.A.	N.A.	N.A.	N.A.
Crude oil and oil products	-4.60%	-8.32%	-2.27%	-4.11%
Natural gas	-3.98%	-8.69%	-1.90%	-4.08%
Electricity	-0.21%	-0.53%	-0.10%	-0.24%
Ferrous, non-ferrous ore and metals	-0.10%	-0.16%	-0.04%	-0.06%
Chemical products	-0.12%	-0.22%	-0.05%	-0.09%
Other energy intensive industries	-0.35%	-0.69%	-0.16%	-0.31%
Electrical goods	-0.07%	-0.11%	-0.03%	-0.04%
Transport equipment	-0.10%	-0.17%	-0.04%	-0.07%
Other equipment goods industries	-0.09%	-0.14%	-0.04%	-0.05%
Consumer goods industries	-0.07%	-0.13%	-0.03%	-0.05%
Building and construction	-0.01%	-0.02%	-0.01%	-0.03%
Telecommunication services	0.09%	0.20%	0.04%	0.07%
Transports	-0.42%	-0.81%	-0.20%	-0.37%
Credit and insurance	0.01%	0.02%	0.00%	0.01%
Other market services	0.02%	0.06%	0.01%	0.01%
Non market services	0.08%	0.17%	0.03%	0.06%

Table 10. Variations in percentage of the production per sector (in real terms) relative to the baseline in the *tax only* and *permits & tax* strategies, under the *high growth* variant

scheme is more equitable than the *tax only* strategy in the sense that ‘losers’ (sectors with decreasing production) almost always lose less, and ‘winners’ (sectors with increasing production) win also less. And from the point of view that sectors losing outnumber the ones winning, the implementation of the *permits & tax* strategy is likely to face less political opposition than the one of the *tax only* scheme.

4.2.5 Foreign trade

The important caveats of Section 4.1.5 should first be recalled. That is GEM-E3 Switzerland is a stand-alone model, where all foreign countries are included in a single ‘Rest of the World’ region. Furthermore, it is assumed that Switzerland is

reducing unilaterally its CO₂ emissions. With these caveats, impacts of the CO₂ emission reduction strategies on foreign trade (in real terms) are given below.

	Tax only		Permits & tax	
	2005	2010	2005	2010
Δ Exports	-0.21%	-0.35%	-0.09%	-0.12%
Δ Imports	-0.19%	-0.35%	-0.09%	-0.18%
Δ Trade balance	-0.25%	-0.36%	-0.07%	-0.04%

Table 11. Variations in percentage of exports, imports and trade balance (Δ exports - Δ imports), relative to the baseline, in the *tax only* and *permits & tax* strategies, under the *high growth* variant

Compared to the *tax only* scheme, the Swiss trade balance is far less deteriorating in the *permits & tax* strategy. This can be explained as follows.

- On the one hand, Swiss exports are decreasing less in the *permits & tax* scheme. As mentioned in Section 4.1.5, the variations from the baseline of the Swiss exports result from different effects. From the perspective of the production factors costs, as already mentioned, two opposite trends take place that affect the Swiss competitiveness. First, energy costs increase less in the *permits & tax* strategy, due to the imposition of a lower carbon tax. Second, labour costs decrease less, due to the domestic recycling of only part of a lower carbon tax revenue. Overall, compared to the baseline, there still are competitiveness losses that lead to a reduction of the Swiss exports in the *permits & tax* scheme, but by a factor more than 2 less than in the *tax only* strategy.
- On the other hand, compared to the baseline, Swiss imports are also decreasing in the *permits & tax* strategy. This again is mainly due to the reduction of fossil fuels imports. But as already mentioned, energy prices increase less in the *permits & tax* scheme. Consequently, fossil fuels imports and beyond total imports are less reduced (by a factor around 2) than in the *tax only* strategy.

Overall, compared to the baseline, the first trend (reduction of exports) dominates slightly (in absolute value) the second one (reduction of imports) in the *permits & tax* scheme. This yields a very small deterioration of the Swiss balance of trade.

4.2.6 Sensitivity analysis on the price of the CO₂ emission permits

A sensitivity analysis has been performed on the price level at which Switzerland buys CO₂ emission permits, see Section 4.2.1. One supposes in this section that Switzerland, through bilateral Clean Development Mechanisms, can buy ‘certified’ CO₂ emission reductions for 10 Swiss francs 1990 per ton CO₂ in 2005 and for 21 Swiss francs in 2010.

Consequences of the reduction (by a factor 2) of the price level of the CO₂ emission permits are given below, compared to the situation for the ‘high’ emission permits price level.

- Impacts on the GDP are further reduced (only a total of 6 million Swiss francs 1990 GDP losses). Indeed, the total abatement cost (reduction of Swiss emissions and buying of emission permits) is here further reduced and so is the overall impact on the Swiss production.
- The employment level is slightly higher (400 more employees). Indeed, labour costs are here further reduced, since a higher amount of the tax revenue is used to reduce social security charges. This means that the ‘double dividend’ is here slightly higher. But it remains lower than in the *tax only* strategy.
- There are very small variations in the production of the 18 sectors (in particular a small increase for the services sectors) due to changes in the relative prices of the production factors. Overall, the sectoral impacts remain lower than in *tax only* strategy.
- There is a very small decrease of exports as well as a very small increase of imports. This yields a deterioration of the Swiss balance of trade, deterioration that remains much lower than in *tax only* strategy.

Two remarks may be formulated from this sensitivity analysis. First, the possibility to buy emission permits at a cheaper price yields as expected an overall better economic situation, in particular in terms of GDP and employment. Second, this possibility is not changing how the *permits & tax* scheme compares to the *tax only* strategy.

5. Conclusions

GEM-E3 is an applied general equilibrium model that analyses the macro-economy and its interaction with the energy system and the environment.

GEM-E3 has been successfully implemented and applied for Switzerland, within the European Research Project *GEM-E3-ELITE* of the European Commission (DGXII). The development of GEM-E3 Switzerland has been funded by the Swiss Federal Office for Education and Science (*Contract Number 97.0475*) and by the Paul Scherrer Institute.

5.1 GEM-E3 Switzerland

GEM-E3 Switzerland is based on the standard version of the GEM-E3 model. This means in particular that perfect competition is assumed to prevail in all markets and that the macro-closure rule it uses is the IS-closure. GEM-E3 Switzerland is furthermore based on the single country version of the GEM-E3 model.

The database of GEM-E3 Switzerland has two parts.

- The Swiss economic database consists mostly of a Social Accounting Matrix (SAM). Such a SAM, compatible with the nomenclature used in GEM-E3, has been adapted by C. Frei from a Swiss SAM developed by the Laboratory of Applied Economics of the University of Geneva, and from statistics specially provided by the Swiss Federal Statistical Office and the Institute for Business Cycle Research (KOF) of the Swiss Federal Institute of Technology.
- The Swiss environmental database consists mainly of an Energy Balance Table and of an Emission Coefficients Table. Both tables have been designed using national and international official statistics, as well as know-how of the PSI GaBE Project.

5.2 Case studies with GEM-E3 Switzerland

The case studies evaluate the curbing of Swiss CO₂ emissions by 10% (by 2010, from the 1990 level). Two strategies to reach this reduction target have been evaluated.

- In the *tax only* strategy, Switzerland imposes the necessary carbon tax to achieve the reduction target, and uses the tax revenue to reduce social security charges.
- In the *permits & tax* strategy, Switzerland combines, to fulfil its reduction target, domestic actions (triggered by a lower carbon tax than in the first strategy) and the buying of emission permits (paid by part of the carbon tax revenue). The remaining of the tax revenue is used, as in the first strategy, to reduce social security charges.

The incentive for the second strategy is the possibility for Switzerland to take advantage of ‘cheap’ emission reduction options that exist in particular in many non-Annexe I countries. One assumes however, in line with a European point of view, that ‘ceilings’ are imposed to the buying of emission reduction options, such that at least 50% of the reduction must be achieved through domestic actions.

Both strategies yield an overall ‘double dividend’ for Switzerland, namely a reduction of its CO₂ emissions (environmental benefit) and an increase of its overall employment level (societal benefit). The employment increase is higher in the *tax only* approach. However, the *permits & tax* strategy leads to lower GDP losses, smaller and more equitable sectoral impacts and a smaller deterioration of the balance of trade. Furthermore, the carbon tax it imposes is reduced compared to the *tax only* strategy, and its implementation should thus face less political opposition.

From this point of view, Switzerland should, to reach a given CO₂ reduction target, consider combining a ‘low’ national carbon tax with the buying of CO₂ emission permits on an international market or through bilateral agreements. Using a different modelling approach, Bahn *et al.* (1998a) were formulating a similar policy recommendation.

5.3 Further development

GEM-E3 Switzerland is a stand-alone model. This implies that all foreign countries are included in a single ‘Rest of the World’ region.

However, the GEM-E3 model exists (in particular) in a European version describing the 15 countries of the European Union. The new European Research Project ENG2-CT1999-00002 *TCH-GEM-E3* aims, among others, at integrating the Swiss model with this European version. This integration will require in particular extensive foreign trade data between Switzerland, the European Union and the ‘Rest of the World’.

This extended European version (Switzerland + 15 EU countries) of GEM-E3 shall be used by the Paul Scherrer Institute to conduct new policy analyses, such as the study of impacts on Switzerland of European energy and environmental policies, and the evaluation of potential gains for policy co-ordination.

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Appendix

This appendix provides selected data from the GEM-E3 Switzerland economic and environmental databases.

The economic database consists mostly of a Social Accounting Matrix (SAM). The complete SAM is divided in two:

- the left-side is given in Appendix 1.1, page 38, and
- the right-side in Appendix 1.2, page 39.

The building of the Swiss SAM is detailed in Appendix 3, page 42.

The environmental database consists mainly of an Energy Balance Table and of an Emission Coefficients Table:

- the Energy Balance Table is given in Appendix 2.1, page 40, and
- the Emission Coefficients Table is given in Appendix 2.2, page 41.

Appendix 1.1 Social Accounting Matrix (1/2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TO TAL
1	1290	0	0	0	0	3	39	58	13	2	15	8471	175	0	3	8	2090	294	12462
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	70	0	818	13	21	43	115	348	44	34	79	160	261	32	535	24	592	173	3364
4	3	0	0	517	3	28	104	130	6	17	24	63	5	9	14	7	112	46	1090
5	139	0	7	34	1194	287	396	523	27	122	149	379	134	62	211	125	1195	230	5213
6	122	0	2	59	199	8055	389	186	2034	1915	3949	712	2091	21	170	19	390	418	20728
7	333	0	5	45	161	408	8591	929	639	180	818	1799	758	17	44	32	1715	645	17119
8	270	0	0	6	22	998	818	5929	687	255	942	1459	5371	273	426	388	6289	987	25122
9	46	0	1	22	76	158	119	119	2393	782	3176	235	659	173	136	113	2301	713	11220
10	113	0	1	18	66	167	193	222	373	2697	3070	229	432	54	330	27	558	1266	9816
11	159	0	2	40	142	324	312	341	2766	3479	6246	463	1091	227	467	140	2859	1979	21036
12	1365	0	1	4	14	217	564	411	893	616	1509	7448	2401	129	180	59	5469	1307	22586
13	560	0	2	105	349	117	107	213	121	170	291	981	1972	288	752	144	7011	2504	15687
14	24	0	1	12	43	104	293	165	256	153	409	333	377	1393	242	409	1963	614	6791
15	98	0	19	53	48	699	815	926	385	245	630	1563	829	432	2905	205	3236	712	13799
16	103	0	1	45	145	113	166	178	297	189	486	367	571	36	508	7281	6971	1315	18771
17	898	0	34	147	477	2237	3686	2832	3451	2519	5969	6575	6032	225	1922	2926	25163	5166	70258
18	33	0	1	13	43	58	169	55	62	70	132	173	99	13	72	48	1645	355	3040
TO TAL	5625	0	895	1134	3004	14016	16874	13562	14448	13444	27892	31410	23257	3382	8919	11956	69560	18725	278102
<i>Transfers</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wages+SSC	2093	0	35	141	1398	5202	5623	6388	5833	5944	11777	10134	17940	4947	10416	15041	55859	37911	196680
Capital	7021	0	26	380	3797	2584	3945	3493	2517	2400	4917	4235	6787	1868	3648	11370	51906	6631	117526
Total Value Added	9114	0	61	522	5195	7786	9568	9881	8350	8344	16694	14369	24727	6815	14063	26411	107765	44542	314205
Actual Output	14739	0	956	1656	8199	21801	26442	23443	22799	21788	44586	45779	47984	10196	22982	38367	177325	63266	592308
HHS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FIRMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Taxes	66	0	1	6	62	56	136	95	124	45	169	1399	292	7	867	2176	616	225	6343
Direct Taxes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Social Security	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subsidies	-1098	0	0	0	-34	2	7	2	3	4	7	-383	0	-8	-2900	9	-1147	0	-5536
VAT taxes	0	0	1	0	20	348	86	406	283	799	1081	746	2300	113	47	-2	3644	0	9871
Duties	313	0	3128	4	0	14	18	8	28	164	192	713	1	0	0	0	0	0	4582
Gov. Foreign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gov. Firms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Taxes	-718	0	3130	10	48	419	247	511	438	1011	1449	2474	2593	113	-1986	2183	3112	225	15260
Distr. Output	14021	0	4086	1666	8247	22221	26689	23954	23236	22799	46036	48253	50577	10309	20996	40550	180437	63492	607567
EC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NON-EC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Imports	3007	0	3840	455	973	9112	11837	7079	10085	12042	22127	18528	869	754	1411	-2	1504	0	103620
Expenditures abroad	2	0	96	1	2	53	46	66	19	17	36	1717	13	188	1657	9	5871	4	9796
Total Imports	3010	0	3936	455	975	9165	11882	7145	10104	12059	22163	20245	881	942	3068	6	7374	5	113415
SAVINGS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Resources	17030	0	8022	2121	9221	31386	38571	31098	33341	34858	68199	68498	51458	11251	24064	40557	187811	63496	720982

Appendix 1.2 Social Accounting Matrix (2/2)

	Labour	Capital	Total	Consumption			FIRMS	Exports	Tourist exp	Total Expd	Investments				Change in Stocks	Total
				Househ.	Govern.	Banks					Househ.	Private	Govern.	Total		
1	0	0	0	4221	0	0	0	329	19	348	0	0	0	0	0	17031
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	4100	0	0	0	49	508	557	0	0	0	0	0	8022
4	0	0	0	1108	0	0	0	10	2	12	0	0	0	0	-90	2120
5	0	0	0	2644	0	0	0	1359	5	1365	0	0	0	0	0	9222
6	0	0	0	858	0	0	0	6705	4	6710	955	1557	665	3176	-87	31386
7	0	0	0	2715	0	0	0	18343	67	18410	0	0	0	0	329	38572
8	0	0	0	3006	0	0	0	2829	97	2925	0	0	0	0	45	31099
9	0	0	0	2864	0	0	0	12649	254	12902	896	4635	263	5795	560	33341
10	0	0	0	3167	0	0	0	10073	8	10080	1752	8555	571	10878	917	34858
11	0	0	0	6031	0	0	0	22721	261	22982	2649	13190	834	16673	1477	68199
12	0	0	0	30493	0	0	0	9789	1045	10833	1439	1753	1069	4261	325	68498
13	0	0	0	941	0	0	0	343	18	361	11709	14267	8699	34675	-205	51457
14	0	0	0	3691	0	0	0	604	165	769	0	0	0	0	0	11251
15	0	0	0	5600	0	0	0	1952	2713	4665	0	0	0	0	0	24065
16	0	0	0	3644	0	12162	0	5957	22	5979	0	0	0	0	0	40556
17	0	0	0	87513	2982	0	0	8460	7673	16132	2430	6572	1394	10396	528	187810
18	0	0	0	16989	43460	0	0	4	15	19	0	0	0	0	-13	63495
TOTAL	0	0	0	179586	46442	12162	0	102175	12874	115049	21830	50529	13495	85854	3786	720981
<i>Transfers</i>	0	0	0	0	0	0	0	0	0	0						0
Wages+SSC	0	0	0	0	0	0	0	0	0	0						196680
Capital	0	0	0	0	0	-12162	0	0	0	0						105364
Total Value Added	0	0	0	0	0	-12162	0	0	0	0						302043
Actual Output	0	0	0	0	0	0	0	0	0	0						592308
HHS	188690	40085	228775	0	51495	0	10040	-439	0	-439						289871
FIRMS	0	57186	57186	-1548	0	0	0	21302	0	21302						76940
Indirect Taxes	0	0	0	0	0	0	0	0	0	0						6343
Direct Taxes	0	0	0	36981	0	0	18931	826	0	826						56738
Social Security	0	0	0	53471	0	0	0	1880	0	1880						55351
Subsidies	0	0	0	0	5536	0	0	0	0	0						0
VAT taxes	0	0	0	0	0	0	0	0	0	0						9871
Duties	0	0	0	0	0	0	0	0	0	0						4582
Gov. Foreign	0	0	0	0	0	0	0	0	0	0						0
Gov. firms	0	8092	8092	0	0	0	0	0	0	0						8092
Total Taxes	0	8092	8092	90452	5536	0	18931	2706	0	2706						140977
Distr. Output	0	0	0	0	0	0	0	0	0	0						607567
EC	0	0	0	0	0	0	0	0	0	0						NA
NON-EC	0	0	0	0	0	0	0	0	0	0						NA
Imports	7990	0	7990	3092	1358	0	0	0	0	0						116060
Expenditures abroad	0	0	0	0	0	0	0	0	0	0						9795
Total Imports	7990	0	7990	3092	1358	0	0	0	0	0						125855
SAVINGS	0	0	0	18288	36146	0	47970	-12763	0	-12763						89641
Total Resources	196680	105363	302043	289870	140977	0	76941	112981	12874	125855	21830	50529	13495	85854	3786	1736513

Appendix 2.1 Energy Balance Table (in PJ)

		SUM	HCL	CKE	LGN	OSF	SOL	CRO	RFG	LPG	GSL	KRS	NFT	GDO	RFO	OLF	LIQ	NGS	OWG	BFG	GASW	GAS	Elec	Biomass		
Bunkers		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
ELE	Elec+Distr. Heat	26.0	17.0	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	3.0	0.0	4.2	4.8	0.0	0.0	0.0	4.8	0.0	0.0	
NENE		128.9	0.0	0.0	0.0	0.0	0.0	128.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	CKO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	BFG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	GAS	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	REF	128.5	0.0	0.0	0.0	0.0	0.0	128.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ENE		6.3	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	5.3	1.0	0.0	0.0	0.0	1.0	19.4	0.0	0.0	
	ENE-SOL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	ENE-LIQ	5.3	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	ENE-GAS	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
	ENE-ELEC	19.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.4	0.0	0.0	
Non Ener		8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Chem	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Other	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
IND		144.1	19.4	1.0	0.0	0.0	20.4	0.0	0.0	4.7	0.2	0.8	2.7	12.6	15.8	1.7	38.6	27.6	0.0	0.0	0.0	27.6	54.8	2.8	0.0	
	1 I&S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	2 non-ferro	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.3	0.0	0.0	0.0	1.3	5.6	0.0	0.0	
	3 chem	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	2.6	1.8	0.0	4.6	8.5	0.0	0.0	0.0	8.5	8.5	0.0	0.0	
	4 building-mat	30.3	17.1	0.3	0.0	0.0	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.8	4.6	0.6	6.0	2.2	0.0	0.0	0.0	2.2	2.5	2.3	0.0	
	5 food,drink&tab	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	0.0	2.3	2.0	0.0	0.0	0.0	2.0	1.7	0.0	0.0	
	6 textile	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.3	0.0	1.7	1.1	0.0	0.0	0.0	1.1	3.9	0.0	0.0	
	7 paper	15.3	1.6	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.4	5.2	0.0	5.6	2.5	0.0	0.0	0.0	2.5	5.4	0.2	0.0	
	8 engineering	27.3	0.5	0.7	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	5.1	1.9	0.0	7.1	6.0	0.0	0.0	0.0	6.0	12.9	0.2	0.0	
	9 other industry	29.4	0.2	0.0	0.0	0.0	0.2	0.0	0.0	4.6	0.2	0.8	2.7	1.6	0.1	1.1	11.0	4.1	0.0	0.0	0.0	4.1	14.2	0.0	0.0	
TRA		253.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	159.3	48.1	0.0	36.7	0.0	0.0	244.2	0.0	0.0	0.0	0.0	0.0	9.3	0.0	0.0	
	rail	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.0	
	road	195.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	159.3	0.3	0.0	35.9	0.0	0.0	195.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	air	47.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.9	0.0	0.0	0.0	0.0	47.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	inland nav	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
HEA		371.0	0.1	0.2	0.0	0.4	0.7	0.0	0.0	0.0	0.7	0.1	0.0	213.5	0.0	0.0	214.4	42.9	0.0	0.0	0.0	42.9	103.7	9.4	0.0	
	Household	221.0	0.1	0.2	0.0	0.4	0.7	0.0	0.0	0.0	0.0	0.1	0.0	135.9	0.0	0.0	136.1	28.5	0.0	0.0	0.0	28.5	47.6	8.2	0.0	
	Agriculture/Fish	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	3.1	0.0	0.0	3.8	0.4	0.0	0.0	0.0	0.4	1.3	0.8	0.0	
	Tertiary	143.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.5	0.0	0.0	74.5	14.0	0.0	0.0	0.0	14.0	54.8	0.4	0.0	

Appendix 2.2 Emission Coefficients Table

ton SO ₂ /PJ	HCL	CKE	LGN	OSF	RFG	LPG	GSL	KRS	GDO	RFO	OLF	NGS	OWG	BFG	GWS
ELE	112.5	500.0	1509.2	500.0	186.8	0.0	0.0	0.0	66.0	120.0	860.0	0.5	293.0	110.0	0.0
ENE	866.3	633.3	1897.9	863.6	76.3	0.0	0.0	0.0	119.1	784.8	790.0	0.5	260.0	110.0	0.0
IND	361.7	500.0	1897.9	500.0	10.0	0.0	66.0	0.0	66.0	440.0	790.0	0.5	260.0	110.0	0.0
TRA	0.0	0.0	0.0	0.0	0.0	0.0	15.0	20.9	61.0	735.3	0.0	0.0	0.0	0.0	0.0
HEA	350.0	350.0	782.8	350.0	0.0	40.0	66.0	31.6	66.0	874.2	0.0	0.5	10.0	0.0	9.0

ton NO _x /PJ	HCL	CKE	LGN	OSF	RFG	LPG	GSL	KRS	GDO	RFO	OLF	NGS	OWG	BFG	GWS
ELE	201.6	250.0	242.0	250.0	140.0	50.0	0.0	0.0	34.0	45.0	294.0	60.0	91.0	61.0	0.0
ENE	208.0	193.0	208.0	193.0	117.5	49.0	0.0	0.0	106.0	114.9	296.0	60.0	91.0	61.0	60.0
IND	232.7	250.0	208.0	250.0	142.0	49.0	80.0	0.0	34.0	111.0	296.0	23.0	91.0	61.0	60.0
Large	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRA	0.0	0.0	0.0	0.0	0.0	107.0	290.2	282.0	360.7	1210.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	107.0	176.0	282.0	259.0	1210.0	0.0	0.0	0.0	0.0	0.0
HDV	0.0	0.0	0.0	0.0	0.0	107.0	937.0	282.0	937.0	1210.0	0.0	0.0	0.0	0.0	0.0
HEA	65.0	65.0	91.0	65.0	0.0	50.0	27.0	50.0	27.0	181.0	0.0	12.0	50.0	0.0	50.0

ton CO ₂ /TJ	HCL	CKE	LGN	OSF	RFG	LPG	GSL	KRS	GDO	RFO	OLF	NGS	OWG	BFG	GWS
ELE	81.5	98.0	99.0	98.0	58.0	65.0	72.0	72.0	73.0	76.0	99.0	55.0	46.0	218.0	59.0
ENE	94.0	108.0	99.0	102.0	68.9	65.0	72.0	72.0	74.0	75.0	99.0	55.0	46.0	218.0	59.0
IND	92.1	98.0	99.0	98.0	58.0	65.0	73.0	72.0	73.0	76.0	99.0	55.0	46.0	218.0	59.0
TRA	94.0	108.0	99.0	102.0	58.0	65.0	72.0	72.0	74.0	78.0	99.0	56.0	46.0	218.0	59.0
HEA	98.0	98.0	99.0	98.0	58.0	65.0	73.0	72.0	73.0	78.0	99.0	55.0	46.0	218.0	59.0

ton NMVOC/PJ	HCL	CKE	LGN	OSF	RFG	LPG	GSL	KRS	GDO	RFO	OLF	NGS	OWG	BFG	GWS
ELE	4.4	9.0	1.5	9.0	0.0	0.0	0.0	0.0	2.0	4.0	0.0	0.1	2.5	0.0	0.0
ENE	1.5	1.5	1.5	1.5	8.3	0.0	0.0	0.0	0.0	6.0	0.0	0.1	2.5	0.0	0.0
IND	7.4	9.0	15.0	9.0	2.5	0.0	2.0	0.0	2.0	4.0	0.0	2.0	2.5	0.0	0.0
Large	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRA	0.0	0.0	0.0	0.0	0.0	144.0	116.9	145.0	57.4	143.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	144.0	117.0	145.0	47.0	143.0	0.0	0.0	0.0	0.0	0.0
HDV	0.0	0.0	0.0	0.0	0.0	144.0	116.0	145.0	116.0	143.0	0.0	0.0	0.0	0.0	0.0
HEA	100.0	100.0	200.0	100.0	0.0	2.0	3.0	3.0	3.0	0.0	0.0	2.0	5.0	0.0	0.0

ton Particulates/PJ	HCL	CKE	LGN	OSF	RFG	LPG	GSL	KRS	GDO	RFO	OLF	NGS	OWG	BFG	GWS
ELE	50.0	50.0	46.4	50.0	0.0	0.0	0.0	0.0	0.2	23.0	0.0	0.2	0.0	0.0	0.0
ENE	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	13.9	0.0	0.2	0.0	0.0	0.0
IND	50.0	50.0	0.0	50.0	0.0	0.0	0.4	0.0	0.2	19.5	0.0	0.1	0.0	0.0	0.0
Large	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Small	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRA	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	50.1	19.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.0	19.0	0.0	0.0	0.0	0.0	0.0
HDV	0.0	0.0	0.0	0.0	0.0	0.0	56.0	0.0	56.0	19.0	0.0	0.0	0.0	0.0	0.0
HEA	150.0	150.0	0.0	150.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.0

Appendix 3.1 Analysis of existing data: SAM-1990

Compared to EUROSTAT, statistical data for Switzerland are relatively poor. Production accounts and I/O tables exist only for 1975, 1985 and 1990³. Changes of nomenclature and systematic⁴ make difficult a consistent use of these data.

Data of the 1990 SAM⁵ of Guillet and Antille (1998) come from different sources. The structure of the MAKE-matrix dates from 1985 and is based on occupational statistics. The structure of the X-matrix dates also from 1985 and is made consistent with 1990 data by a RAS-filter. The USE matrix is derived from the MAKE and the X-matrix. Final household consumption is based on a survey on household budgets for 1990. The structure of investment in equipment is based on a *commodity flow method* analysis for 1985; the structure of investment in construction dates from 1975. Import/export data are provided by the Swiss Federal Customs Office (SH⁶ nomenclature) and other macro-economic data are provided by the Swiss Federal Statistical Office. Observations are generally based on demand market prices; commercialisation fees had to be estimated (structural data from Denmark).

The building of the Swiss economic database has required the elaboration of a 1990 SAM, consistent with the 18-sectors GEM-E3 nomenclature that is based on the NACE⁷ nomenclature. However, the 1990 SAM of Guillet and Antille (1998) is based on the NGAE⁸ nomenclature. The Swiss Federal Statistical Office publishes only a *theoretical* (i.e., non-weighted) translation key from NGAE to the NOGA⁹ nomenclature, that is consistent with NACE. This implies that some sector-aggregates (such as Electricity-Gas-Water) had to be disaggregated in a bottom-up approach.

Appendix 3.2 Disaggregation steps

Disaggregation of value added per economic branch

The GEM-E3 sector aggregates are:

1. Agricultural, forestry and fishery products;
2. Solid fuels (i.e., coal, lignite and briquettes, and coking products);
3. Liquid fuels (i.e., crude oil and oil products);
4. Natural gas and manufactured gases;

³ A new production account will hopefully be available by the year 2000 (for the year 1997).

⁴ SNA: System on National Accounts.

⁵ This SAM details 37 sectors and 8 consumption purposes.

⁶ *Système Harmonisé de Désignation et de Codification des Marchandises*, used since 1998.

⁷ General industrial classification of economic activities within the European Union.

⁸ *Nomenclature Générale des Activités Economiques*.

⁹ NOGA is a five-digit nomenclature, where the first four digits correspond to the four-digit NACE nomenclature. That is to say, the sum of all five-digit NOGA products with the same first four digits correspond to the NACE product.

5. Electricity, nuclear fuels, steam, hot water and compressed air;
6. Ferrous and non-ferrous ore, and metals other than radioactive;
7. Chemical products;
8. Other energy intensive industries (i.e., non-metallic minerals and mineral products, metal products except machinery and transport equipment, paper and printing products);
9. Electrical goods;
10. Transport equipment (i.e., motor vehicles and engines, other transport equipment);
11. Other equipment goods industries (agricultural and industrial machinery, office and data processing machines, precision and optical instruments);
12. Consumer goods industries (food, beverages and tobacco; textiles and clothing, timber and wooden furniture, leather and footwear, rubber and plastic products, other manufacturing products);
13. Building and construction;
14. Telecommunication services;
15. Transports (inland, maritime and air transports, auxiliary transport services);
16. Services of credit and insurance institutions;
17. Other market services (recovery and repaired services, wholesale and retail trade services, lodging and catering services, water collection, purification and distribution, other market services);
18. Non-market services.

The disaggregation is based on original 1990 data (38 sectors), specially prepared by the Swiss Federal Statistical Office. The value added is split into:

- A. Salaries;
- B. Gross cash flow including capital cost;
- C. Imputed 'production' of the banking service;
- D. Production taxes (excluding VAT and ICHA);
- E. Exploitation subsidies;
- F. ICHA on products;
- G. GVA: Gross Value Added (without net importation taxes and ICHA);

Unfortunately, there is no data available that make it possible to separate B into capital cost, amortisation, profit, etc. In the GEM-E3 model anyway, one applies homogenous default values to perform this disaggregation.

Dis- and re-aggregation of consumption categories

The GEM-E3 compatible consumption categories are:

1. Food, beverages and tobacco;
2. Clothing and footwear;
3. Housing and water;
4. Fuels and power;
5. Housing furniture and operation;
6. Heating and cooking appliances;
7. Medical care and health expenses;
8. Transport equipment;
9. Operation of transport equipment;
10. Purchased transport;
11. Telecommunication services;
12. Recreation, entertainment, culture, etc.;
13. Other services.

The final household consumption is based on a survey on 1990 household budgets on 280 categories¹⁰. The original data allow for a definition of specific consumption sets. These are evaluated in demand market prices. Commercialisation fees have to be estimated and deduced to obtain expenditures valued in supply market prices. Due to the lack of Swiss specific data, the estimation of the commercialisation fees is based on Danish data. These data have been applied simply because of the availability of product-specific commercialisation fee rates for Denmark¹¹.

Disaggregation of Investment per Economic Branch

There is no official Swiss investment matrix available. This section describes the estimation of such a matrix and illustrates the suggested assumptions. Specific investment for focused sectors may be estimated in a bottom-up approach based on a survey. But this (huge) task does exceed by far the time frame allocated for this research project.

Box 1, page 45, summarises the different sources used and the problems related to using different sources.

The official statistics (VGR) include specific data on investment for each institutional sector.

S10 is provided by both statistics, VGR and HR. However, HR data have to be enriched by data on the agricultural sector, the electricity/gas/water sector and on the extracting sector. Those data are taken as far as possible from sector internal statistics. The total amount of investment on equipment within S10 differs then by +16.4% from

¹⁰ Swiss Federal Statistical Office (1991). *Enquête sur les Budgets des Ménages pour 1990 Comprenant 280 Rubriques de Dépenses*, Bern, Switzerland.

¹¹ See Guillet and Antille (1998).

- Main sources: VGR¹² and HR¹³. These two statistics are based on different methods. VGR is based on a *commodity flow method*. HR extrapolates survey data of 9000 companies by their full-time job equivalents.
- In the official VGR, there is a disaggregation of investment into construction and equipment per institutional sector¹⁴.
- HR includes the institutional sectors S10 (-), S40 and S50. S10 is inventoried without the agricultural sector¹⁵, the electricity/gas/water aggregate¹⁶ and without the extracting sector¹⁷. HR does not consider leasing whereas VGR does.
- The Swiss Farmers Association provides data for the agricultural sector¹⁸.
- Total investment data for the electricity sector are taken from official statistics¹⁹. The split between equipment and construction is based on a LASEN survey. An estimation of the private part of the total investment is based on the private social capital share, also from official statistics.
- The Swiss Gas Industry Association provides data for the gas sector²⁰.
- Structural data of investment in equipment on a national level are based on a *commodity flow method* analysis. Structural data of investment in construction are based on data from 1975²¹.
- Volumes include ICHA/VAT²².
- Sectors are not homogenised, companies are grouped according to their main activity.

Box 1. Sources used and related problems

the official data and the total amount of investment on construction by +6.1%. These differences are within the data scattering due to extrapolation, according to the Swiss Federal Statistical Office and KOF.

The 26 S10 sectors of HR are disaggregated into the 32 S10 sectors of the existing I/O table according to their full-time job equivalents. Reparation is also split and re-affected consistently to what has been done for the existing I/O table. To obtain consistency with the rest of the national accounts (i.e., with the official S10 investment data), the structure of these enriched HR data is taken and applied to the official S10 amounts.

¹² VGR: *Volkswirtschaftliche Gesamtrechnung* 1990.

¹³ HR: KOF/ETH – *Investitionshochrechnung* 1990.

¹⁴ Institutional sectors: non-financial companies (S10), banks (S40), insurance companies (S50), public administration (S60), social insurance (S70), households (S81) and non-market services (S82).

¹⁵ SFSO 85, ASWZ/NGAE, sector 0.

¹⁶ SFSO 85, ASWZ/NGAE, sector 11.

¹⁷ SFSO 85, ASWZ/NGAE, sector 12.

¹⁸ Swiss Farmers Association (1998). *Comptes Economiques de l'Agriculture de la Suisse pour les Années 1990-1997*, Brugg, Switzerland.

¹⁹ Swiss Federal Office of Energy (1992). *Statistique Suisse de l'Electricité 1991*, Bern, Switzerland.

²⁰ Swiss Gas Industry Association (1990). *Statistique annuelle de l'Association Suisse de l'Industrie Gazière*, Zurich, Switzerland.

²¹ See Guillet and Antille (1998).

²² ICHA (*Impôt sur le Chiffre d'Affaires*) was a tax on turnover. It was replaced in January 1995 by a value added tax (VAT).

VGR and HR provide data for S40 and S50, but they show significant differences that are mainly due to the different methods applied for their evaluation. For consistency reasons with the rest of the national accounts, the official figures from VGR are taken.

The Swiss Federal Statistical Office provides amounts for S60, S70 and S81/82.

A table summarising the application of the mentioned assumptions on the data is given below.

NCT	SFSO 85/ VGR	KOF/ HR	Nomenclature	# 100%- jobs	% splitting		MFr./yr in equipment	MFr./yr in construction
1	0		Agriculture, sylviculture (Source: Comptes Economiques de l'Agriculture de la Suisse pour les années 1990-1997, Schweizerischer Bauernverband SBV, Brugg 1998)	138101	100.0%		887.9	508.7
2	11		Production et distribution d'électricité, de gaz et d'eau (seulement investissements privés!)	24923	100.0%		138.8	264.5
			Production d'électricité (selon statistique OFEN)			Tot. 461.0	43.6	80.9
			Transmission et distribution d'électricité (selon statistique OFEN)			Tot. 797.0	75.3	139.9
			Immobilier, mobilier, appareils pour le secteur électrique (selon statistique OFEN)			Tot. 178.0	16.8	31.2
			Estimation de structure (selon enquête du LASEN)				35.0%	65.0%
			Estimation de la partie privée (selon l'origine du capital social)				27.0%	27.0%
			Transport de gaz (selon la statistique du secteur gazière)			Tot. 40.0	0.8	3.2
			Distribution de gaz (selon la statistique du secteur gazière)			Tot. 116.0	2.3	9.3
			Estimation de structure (selon estimation de l'Association Suisse de l'Industrie Gazière)				20.0%	80.0%
			Estimation de la partie privée (selon estimation de l'Association Suisse de l'Industrie Gazière)				10.0%	10.0%
			Production et distribution d'eau: négligées; en major part propriété publique					
3+4+5	21+22+23	1	Nahrungs- und Genussmittel	69917	100.0%		993.0	578.0
3	21		Industrie des produits alimentaires	57885	82.8%		822.1	478.5
4	22		Industrie des boissons	8416	12.0%		119.5	69.6
5	23		Industrie du tabac	3616	5.2%		51.4	29.9
	24	2	Textil	29356	100.0%		313.0	115.0
6	24-2414		Industrie textile (sans les textiles synthétiques)	24734	84.3%		263.7	96.9
	2414		textiles synthétiques		15.7%		49.3	18.1
7+12 sans réparations	25+29	3	Bekleidung und Leder	25077	100.0%		104.0	47.0
7 sans réparations	25		Industrie de l'habillement et de la lingerie	18674	74.5%		77.4	35.0
7	25+R		Industrie de l'habillement et de la lingerie + réparations				80.2	38.6
12 sans réparations	29		Industrie du cuir et de la chaussure	6404	25.5%		26.6	12.0
12	29+R		Industrie du cuir et de la chaussure + réparations				27.5	13.2
	26	4	Holz und Möbel	66037	100.0%		505.0	174.0
8	26-261		Industrie du bois et du meuble en bois (sauf 261)	59351	89.9%		453.9	156.4
9	261		Sciage et préparation industrielle du bois		10.1%		51.1	17.6
	27	5	Papier	16175	100.0%		522.0	87.0
10	27		Papier, carton	16175	100.0%		522.0	87.0
	28	6	Grafik	63389	100.0%		749.0	175.0
11	28		Arts graphiques	63389	100.0%		749.0	175.0
	31	7	Chemie	73717	100.0%		1481.0	563.0
13 sans 2414	31-314		Industrie chimique (sauf 314)	73246	99.4%		1471.5	559.4
13	31-314+2414		Industrie chimique (sauf 314); textiles synthétiques				1520.8	577.5
14	314		Raffinage de pétrole		0.6%		9.5	3.6
	32	8	Kunststoffe	24654	100.0%		512.0	143.0
15	32		Industrie des matières plastiques et du caoutchouc	24654	100.0%		512.0	143.0
16 sans 12	33	9	Steine und Erden	32096	100.0%		604.0	324.0
16 sans 33	12		Extraction (ne pas considéré par la HR; Hyp: dito 33)	466	1.5%		8.8	4.7
16	33+12		Industrie des produits minéraux non métalliques; extraction de sel et minéraux	32562	101.5%		612.8	328.7
	34	10	Metall	101069	100.0%		1063.0	385.0

Appendix 3. Building of a GEM-E3 compatible Swiss SAM

NCT	SFSO 85/ VGR	KOF/ HR	Nomenclature	# 100%- jobs	% splitting	MFr./yr in equipment	MFr./yr in construction
17 sans réparations		34	Métallurgie	101069	100.0%	1063.0	385.0
17	34+R		Métallurgie + réparations			1063.0	385.0
		35	Maschinen	158682	100.0%	1131.0	590.0
18 sans réparations		35	Construction de machines et de véhicules	158682	100.0%	1131.0	590.0
18	35+R		Construction de machines et de véhicules + réparations			1349.6	872.5
		36	Elektro	130492	70.4%	1098.0	252.0
		37	Uhren	36832	19.9%	259.0	66.0
		38	sonstige Industrie	18122	9.8%	123.0	29.0
19 sans réparations		36+37+38	Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières	185446	100.0%	1480.0	347.0
19	36+37+38+R		Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières + réparations			1534.2	417.1
		41	Bauhauptgewerbe	191778	100.0%	1210.0	352.0
20	41		Construction proprement dite	191778	100.0%	1210.0	352.0
		42	Ausbau-gewerbe	149630	100.0%	522.0	207.0
21	42		Aménagement et parachèvement	149630	100.0%	522.0	207.0
		17	Grosshandel	197123	100.0%	2140.0	1110.0
22 sans réparations		51+52+53+54	Commerce de gros; intermédiaires du commerce	197123	100.0%	2140.0	1110.0
22	51+52+53+54+R		Commerce de gros; intermédiaires du commerce + réparations			2140.0	1110.0
		55+56	Detailhandel	312398	100.0%	1387.0	2047.0
23 sans réparations		55+56	Commerce de détail	312398	100.0%	1387.0	2047.0
23	55+56+R		Commerce de détail + réparations			1387.3	2047.4
		57	Gastgewerbe	203245	100.0%	687.0	1038.0
24	57		Restauration et hébergement	203245	100.0%	687.0	1038.0
		58	Reparatur	76238	100.0%	277.0	358.0
7	25	->	Industrie de l'habillement et de la lingerie + réparations		1.0%	2.8	3.6
12	29	->	Industrie du cuir et de la chaussure + réparations		0.3%	0.9	1.2
17	34	->	Métallurgie + réparations		0.0%	0.0	0.0
18	35	->	Construction de machines et de véhicules + réparations		78.9%	218.6	282.5
19	36+37+38	->	Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières + réparations		19.6%	54.2	70.1
22	51+52+53+54	->	Commerce de gros; intermédiaires du commerce + réparations		0.0%	0.0	0.0
23	55+56	->	Commerce de détail + réparations		0.1%	0.3	0.4
32	74+75+76+84+85+87	->	Locat. de biens mob., crédit-bail; bureaux de consultat., serv. commerciaux et informatiques; serv. personnels; voirie, assainissement; hébergement soc., oeuvres soc.; serv. fournis à la collectivité, organismes de défense d'intérêts + réparations		0.0%	0.1	0.1
33	81+82+88	->	Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements + réparations		0.0%	0.0	0.0
		21	Verkehr	130133	100.0%	2503.0	2322.0
25	61		Chemin de fer, chemin de fer de montagne et funiculaires	47742	36.7%	918.3	851.9
26 sans 65		62+64	Transport routier, par pipe-line; aérien; interméd. du domaine des transports, dépôts, entrepôts	79521	61.1%	1529.5	1418.9
26	62+64+65		Transport routier, par pipe-line; aérien; interméd. du domaine des transports, dépôts, entrepôts			1637.5	1474.9
27	63		Navigation	2871	2.2%	55.2	51.2
		22	Verkehrsvermittlung	21575	100.0%	108.0	56.0
		65	Interméd. des transports	21575	100.0%	108.0	56.0
		23	Nachrichtenübermittlung	68594	100.0%	3161.0	440.0
28	66		Communications	68594	100.0%	3161.0	440.0
		24	Banken	127316	100.0%	1317.0	1529.0
29	71		Banques, sociétés financières	127316	100.0%	1317.0	1529.0
			Source: VGR/S40				
		25	Versicherungen	47809	100.0%	310.0	680.0
30	72		Assurances	47809	100.0%	290.0	673.0
			Source: VGR/S50				
		26	Immobilien und Leasing	19883	100.0%	148.0	1911.0
31	73+74		Affaires immobilières; location d'immeubles (ménages et assurances sociales)	15577	78.3%	115.9	1497.1
		73+XX					

NCT	SFSO 85/ VGR	KOF/ HR	Nomenclature	# 100%- jobs	% splitting	MFr./yr in equipment	MFr./yr in construction
32 sans réparations, sans 75, 76, 84, 85, 87	74		Location de biens mobiliers	4306	21.7%	32.1	413.9
	75+76	27	Beratung und Informatik	247670	100.0%	1360.0	271.0
	75		Bureaux de consultation	194245	78.4%	1066.6	212.5
	76		Services personnels	53425	21.6%	293.4	58.5
	81+82+83+84+85 +87+88	28	sonstige Dienstleistungen	161926	100.0%	1485.0	1187.0
32 sans réparations, sans 74, 75, 76	84+85+87		Locat. de biens mob., crédit-bail; bureaux de consultat., serv. commerciaux et informatiques; serv. personnels; voirie, assainissement; hébergement soc., oeuvres soc.; serv. fournis à la collectivité, organismes de défense d'intérêts	18118	11.2%	166.2	132.8
32	74+75+76+84+85 +87+R		Locat. de biens mob., crédit-bail; bureaux de consultat., serv. commerciaux et informatiques; serv. personnels; voirie, assainissement; hébergement soc., oeuvres soc.; serv. fournis à la collectivité, organismes de défense d'intérêts + réparations			1558.3	817.7
33 sans réparations	81+82+88		Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements	42279	26.1%	387.7	309.9
33	81+82+88+R		Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements + réparations			387.8	310.0
34	83		Service de santé et service vétérinaire	101528	62.7%	931.1	744.3
35	86 + 89		Institutions sans but lucratif, services domestiques	83135		704.0	1270.0
			Source: VGR/S82				
36	91		Administrations publiques	350683		1076.0	10546.0
			Source: VGR/S60				
37	92		Assurances sociales	13820		109.0	982.0
			Source: VGR/S70				
HH			Ménages			6054.0	15776.0
			Source: VGR/S81				

Code	Source
109.0	SFSO, official statistics from national accounts
42279	SFSO, unofficial data
797.0	Branch specific statistics, sources indicated
42279	KOF, unofficial data
19.6%	LEA structural hypothesis
27.00%	LASEN hypothesis
387.8	Evaluated data with given information

Table 12. Underlying assumptions for the disaggregation of investment

The branch specific investment may be of less interest than the function specific investment.²³ To obtain an estimation of the function specific investment, the same transformation is applied as for the evaluation of the X-matrix of intermediate consumption.

$$Inv_{functional} = Inv_{branch} \cdot V^{T-1} \cdot \hat{q}, \text{ where}$$

V : MAKE or production matrix (branches * products);

\hat{q} : The diagonalised vector of specific production per product.

The underlying assumption is that investment for a specific function is independent of the branch in which the action takes place.

A table comparing branch specific investments and function specific investments is given below.

²³ The national accounting of most European countries is based on the 'concentration principle' (*Schwerpunktprinzip basierend auf Unternehmungen*), which assigns companies according to their main activity. This does not allow for a consistent analysis of specific functional sectors (*Funktionalprinzip, basierend auf Betrieben*).

Results and Comparison of Function versus Branch Specific Investments			Branch specific data		Function specific data (trafo dito MAKE)	
Position NCT	Position SFSO 85	Classes économiques	MFr. investment in			
			equipment	construction	equipment	construction
1	0	Agriculture, sylviculture	1'012.8	526.0	1'012.8	526.0
2	11	Production et distribution d'électricité, de gaz et d'eau	158.4	273.5	157.6	277.2
3	21	Industrie des produits alimentaires	937.8	494.8	976.1	503.0
4	22	Industrie des boissons	136.4	72.0	131.8	66.4
5	23	Industrie du tabac	58.6	30.9	55.4	29.4
6	24-2414	Industrie textile (sans les textiles synthétiques)	300.8	100.2	292.9	91.9
7	25	Industrie de l'habillement et de la lingerie + réparations	91.5	39.9	91.2	38.6
8	26-261	Industrie du bois et du meuble en bois (sauf 261)	517.7	161.7	527.4	150.1
9	261	Sciage et préparation industrielle du bois	58.3	18.2	60.6	18.4
10	27	Papier, carton	595.5	90.0	627.6	93.6
11	28	Arts graphiques	854.4	181.0	855.7	174.1
12	29	Industrie du cuir et de la chaussure + réparations	31.4	13.7	29.2	12.1
13	31-314+2414	Industrie chimique (sauf 314); textiles synthétiques	1'734.8	597.2	1'724.2	584.5
14	314	Raffinage de pétrole	10.8	3.7	10.8	3.7
15	32	Industrie des matières plastiques et du caoutchouc	584.0	147.9	595.3	151.1
16	12+33	Industrie des produits minéraux non métalliques; extraction de sel et minéraux	699.0	339.9	712.2	341.6
17	34	Métallurgie + réparations	1'212.6	398.2	1'200.5	383.2
18	35	Construction de machines et de véhicules + réparations	1'539.5	902.3	1'514.6	883.2
19	36+37+38	Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières + réparations	1'750.1	431.3	1'695.0	399.5
20	41	Construction proprement dite	1'380.3	364.0	1'347.1	320.1
21	42	Aménagement et parachèvement	595.5	214.1	598.5	198.3
22	51+52+53+54	Commerce de gros; intermédiaires du commerce + réparations	2'441.2	1'147.9	2'486.8	1'098.3
23	55+56	Commerce de détail + réparations	1'582.5	2'117.2	1'484.5	2'030.3
24	57	Restauration et hébergement	783.7	1'073.4	791.3	1'085.0
25	61	Chemin de fer, chemin de fer de montagne et funiculaires	1'047.5	880.9	1'048.7	880.8
26	62+64+65	Transport routier, par pipe-line; aérien; interméd. du domaine des transports, dépôts, entrepôts	1'867.9	1'525.2	1'919.3	1'555.4
27	63	Navigation	63.0	53.0	63.0	52.9
28	66	Communications	3'605.8	455.0	3'606.0	455.0
29	71	Banques, sociétés financières / S40	1'836.0	1'335.0	1'814.8	1'252.3
30	72	Assurances / S50	290.0	673.0	280.5	562.7
31	73+XX	Affaires immobilières; location d'immeubles (ménages et assurances sociales)	132.3	1'548.2	192.7	2'269.9
32	74+75+76+84+85+87	Locat. de biens mob., crédit-bail; bureaux de consultat., serv. commerciaux et informatiques; serv. personnels; voirie, assainissement; hébergement soc., oeuvres soc.; serv. fournis à la collectivité, organismes de défense d'intérêts + réparations	1'777.5	845.6	1'775.9	790.0
33	81+82+88	Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements + réparations	442.3	320.5	466.5	334.1
34	83	Service de santé et service vétérinaire	1'062.1	769.6	1'063.8	768.8
35	86 + 89	Institutions sans but lucratif, services domestiques / S82	704.0	1'270.0	703.1	1'236.5
36	91	Etat / S60	1'076.0	10'546.0	1'070.8	10'484.4
37	92	Assurances sociales / S70	109.0	982.0	97.0	840.7
HH		Ménages / S81	6'054.0	15'776.0	6'054.0	15'776.0
TOT	TOT	Total	39'135.0	46'719.0	39'135.0	46'719.0

Table 13. Function versus branch specific investment

Finally, the next table summarises the results obtained and compares HR and VGR.

Results and Comparison of HR and VGR (branch specific investment)			HR data, enriched with sectoral data		(1): structure from enriched HR data; only S10		VGR data, (1) applied to VGR S10 amounts	
Position NCT	Position SFSO 85	Classes économiques	MFr. investment in		equipment	construction	equipment	construction
			equipment	construction	equipment	construction	equipment	construction
1	0	Agriculture, sylviculture	887.9	508.7	3.48%	3.26%	1'012.8	526.0
2	11	Production et distribution d'électricité, de gaz et d'eau	138.8	264.5	0.54%	1.69%	158.4	273.5
3	21	Industrie des produits alimentaires	822.1	478.5	3.23%	3.07%	937.8	494.8
4	22	Industrie des boissons	119.5	69.6	0.47%	0.45%	136.4	72.0
5	23	Industrie du tabac	51.4	29.9	0.20%	0.19%	58.6	30.9
6	24-2414	Industrie textile (sans les textiles synthétiques)	263.7	96.9	1.03%	0.62%	300.8	100.2
7	25	Industrie de l'habillement et de la lingerie + réparations	80.2	38.6	0.31%	0.25%	91.5	39.9
8	26-261	Industrie du bois et du meuble en bois (sauf 261)	453.9	156.4	1.78%	1.00%	517.7	161.7
9	261	Sciage et préparation industrielle du bois	51.1	17.6	0.20%	0.11%	58.3	18.2
10	27	Papier, carton	522.0	87.0	2.05%	0.56%	595.5	90.0
11	28	Arts graphiques	749.0	175.0	2.94%	1.12%	854.4	181.0
12	29	Industrie du cuir et de la chaussure + réparations	27.5	13.2	0.11%	0.08%	31.4	13.7
13	31-314+2414	Industrie chimique (sauf 314); textiles synthétiques	1'520.8	577.5	5.97%	3.70%	1'734.8	597.2
14	314	Raffinage de pétrole	9.5	3.6	0.04%	0.02%	10.8	3.7
15	32	Industrie des matières plastiques et du caoutchouc	512.0	143.0	2.01%	0.92%	584.0	147.9
16	12+33	Industrie des produits minéraux non métalliques; extraction de sel et minéraux	612.8	328.7	2.40%	2.11%	699.0	339.9
17	34	Métallurgie + réparations	1'063.0	385.0	4.17%	2.47%	1'212.6	398.2
18	35	Construction de machines et de véhicules + réparations	1'349.6	872.5	5.30%	5.59%	1'539.5	902.3
19	36+37+38	Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières + réparations	1'534.2	417.1	6.02%	2.67%	1'750.1	431.3
20	41	Construction proprement dite	1'210.0	352.0	4.75%	2.26%	1'380.3	364.0
21	42	Aménagement et parachèvement	522.0	207.0	2.05%	1.33%	595.5	214.1
22	51+52+53+54	Commerce de gros; intermédiaires du commerce + réparations	2'140.0	1'110.0	8.40%	7.11%	2'441.2	1'147.9
23	55+56	Commerce de détail + réparations	1'387.3	2'047.4	5.44%	13.12%	1'582.5	2'117.2
24	57	Restauration et hébergement	687.0	1'038.0	2.70%	6.65%	783.7	1'073.4
25	61	Chemin de fer, chemin de fer de montagne et funiculaires	918.3	851.9	3.60%	5.46%	1'047.5	880.9
26	62+64+65	Transport routier, par pipe-line; aérien; interméd. du domaine des transports, dépôts, entrepôts	1'637.5	1'474.9	6.43%	9.45%	1'867.9	1'525.2
27	63	Navigation	55.2	51.2	0.22%	0.33%	63.0	53.0
28	66	Communications	3'161.0	440.0	12.41%	2.82%	3'605.8	455.0
29	71	Banques, sociétés financières / S40	1'317.0	1'529.0			1'836.0	1'335.0
30	72	Assurances / S50	310.0	680.0			290.0	673.0
31	73+XX	Affaires immobilières; location d'immeubles (ménages et assurances sociales)	115.9	1'497.1	0.46%	9.59%	132.3	1'548.2
32	74+75+76+84+85+87	Locat. de biens mob., crédit-bail; bureaux de consultat., serv. commerciaux et informatiques; serv. personnels; voirie, assainissement; hébergement soc., oeuvres soc.; serv. fournis à la collectivité, organismes de défense d'intérêts + réparations	1'558.3	817.7	6.12%	5.24%	1'777.5	845.6
33	81+82+88	Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements + réparations	387.8	310.0	1.52%	1.99%	442.3	320.5
34	83	Service de santé et service vétérinaire	931.1	744.3	3.65%	4.77%	1'062.1	769.6
35	86 + 89	Institutions sans but lucratif; services domestiques / S82	704.0	1'270.0			704.0	1'270.0
36	91	Etat / S60	1'076.0	10'546.0			1'076.0	10'546.0
37	92	Assurances sociales / S70	109.0	982.0			109.0	982.0
HH		Ménages / S81	6'054.0	15'776.0			6'054.0	15'776.0
TOT	TOT	Total	35'050.5	46'387.9	100.00%	100.00%	39'135.0	46'719.0

Table 14. Results and comparison of HR and VGR

Now, one has an estimate of how much each sector spends for which of the two types of investment. But how does a specific ‘investment good—equipment’ or ‘investment good—construction’ look like? Which sectors provide the demanded investment goods?

The specific shares depend on the investing sector, but there is no specific data available for Switzerland. To obtain an estimation of the investment matrix, one may apply the structure of the (estimated) national investment good type to each of the sectors. However, to assume the same investment structure (e.g., for banks and for agriculture) is quite a rough assumption. But a better estimation could hardly be done with the existing statistical data.²⁴

$$M_{Inv} = G_{Inv} \cdot Inv^T;$$

M_{Inv} : 18x19 investment matrix;

G_{Inv} : 18x2 investment function structures for national equipment and construction good;

Inv : 19x2 function (or branch) specific data (including households at position 19) on expenditures on annual equipment and construction investments.

Separation of Exportation and Importation into EU and ROW

Import/export data are provided in SH nomenclature by the Swiss Federal Customs Office. This nomenclature of the custom inventory is not consistent with the NGAE or NOGA nomenclatures.

Notice that S. Guillet and G. Antille have made a major non-published work on this topic. The results of this study may be available on request.

Splitting of Electricity/Gas/Water

Communities traditionally do the distribution of electricity, gas and water in Switzerland. Therefore, economic data on these activities have not been separated until very recently. This explains why, at the national level, data on electricity, gas and water remain available only in an aggregate form.

A bottom-up approach may provide sector specific data. According to the methodology applied by the Swiss Federal Statistical Office, the analysed sample may be referred to and extrapolated following the representative full-time jobs. There is the possibly of weighting for different production types or/and sizes within the same sector. However, the needed time exceeded by far the time frame allocated for this research project.

²⁴ We do not recommend to go beyond the sector specific disaggregation of the investment into equipment and construction, as far as model features allow this.

KOF²⁵ has disaggregated electricity, gas and water, based on data from different sources such as official statistics, energy perspectives, etc. Unfortunately the results are not consistent with the national accounts.

In the given time frame, a complete re-evaluation of these data was not possible. Structural data were taken from the mentioned study and adapted to fit the figures of the national accounts, i.e., to fit the aggregate electricity-gas-water of the existing SAM.

Transportation Services

The national accounting of most European countries is based on the ‘concentration principle’, that assigns companies according to their main activity. This may not allow for a consistent analysis of a specific functional sector.

In GEM-E3, the transportation sector, for instance, does not include commercial transportation activities provided by sectors with other main activities. Only transportation companies appear in the transportation sector. To model correctly traffic scenarios they should, however. Notice that in Switzerland, KOF²⁶ has made such an attempt.

Appendix 3.3 Re-aggregation steps

Re-aggregation into the GEM-E3 Compatible Sectors

The re-aggregation of the obtained 38 sectors in the 18 GEM-E3 sectors is done by a double linear transformation. The transformation matrix is given in Table 15, page 53.

Sectors 2A, 2B and 2C are obtained by disaggregating sector 2 of the original SAM, using as far as possible structural data from KOF.

Sectors 18 (‘construction of machines and vehicles’) and 19 (‘electric, electronic and optic construction, and other manufacture industries’) have to be split into GEM-E3 sectors 9 (‘electrical goods’), 10 (‘transport equipment’, i.e., motor vehicles and engines, other transport equipment) and 11 (‘other equipment goods industries’, i.e., agricultural and industrial machinery, office and data processing machines, precision and optical instruments). Lacking information for this disaggregation, a simple fifty-fifty split has been applied as a rough estimate.

Sectors 25 and 27 are already aggregated to make comparison with KOF data possible.

²⁵ Schnewlin, M. (1990). *Disaggregation der Transportbranche zwecks Erstellung der I/O-Tabelle Schweiz 1985*, Arbeitspapier Nr. 27, Konjunkturforschungsstelle der Eidgenössisch Technischen Hochschule (KOF/ETH), Zürich, Switzerland; and

Schnewlin, M. (1996) *Ein input-output basiertes Produktionsmodell der Schweiz für 1990 mit besonderer Berücksichtigung der Energie- und Verkehrswirtschaft*, Konjunkturforschungs-stelle der Eidgenössisch Technischen Hochschule (KOF/ETH), Zürich, Switzerland.

²⁶ See again Schnewlin (1990, 1996).

No	Branches	GEM-E3 Sectors																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Agriculture, sylviculture	1																	
2A	Production et distribution d'électricité				1														
2B	Production et distribution de gaz			1															
2C	Production et distribution d'eau																	1	
3	Industrie des produits alimentaires											1							
4	Industrie des boissons											1							
5	Industrie du tabac											1							
6	Industrie textile (sans les textiles synthétiques)											1							
7	Industrie de l'habillement et de la lingerie + réparations											1							
8	Industrie du bois et du meuble en bois (sauf 261)											1							
9	Sciage et préparation industrielle du bois												1						
10	Papier, carton								1										
11	Arts graphiques								1										
12	Industrie du cuir et de la chaussure + réparations												1						
13	Industrie chimique (sauf 314); textiles synthétiques							1											
14	Raffinage de pétrole			1															
15	Industrie des matières plastiques et du caoutchouc												1						
16	Industrie des produits minéraux non métalliques; extraction de sel et minéraux							1											
17	Métallurgie + réparations						1												
18	Construction de machines et de véhicules + réparations										0.5	0.5							
19	Construction électrique, électronique et optique; horlogerie, bijouterie, ateliers de gravure et de frappe; autres industries manufacturières + réparations									0.5	0.5								
20	Construction proprement dite													1					
21	Aménagement et parachèvement													1					
22	Commerce de gros; intermédiaires du commerce + réparations																		1
23	Commerce de détail + réparations																		1
24	Restauration et hébergement																		1
25 + 27	Chemin de fer, chemin de fer de montagne et funiculaires, navigation																	1	
26	Transport routier, par pipe-line; aérien; interméd. du domaine des transports, dépôts, entrepôts																	1	
28	Communications																	1	
29	Banques, sociétés financières																		1
30	Assurances																		1
31	Affaires immobilières; location d'immeubles (ménages et assurances sociales)																		1
32	Location de biens mobiliers, crédit-bail; bureaux de consultation, services commerciaux et informatiques; services personnels; voirie, assainissement; hébergement social, oeuvres																		1
33	Enseignement; R&D (non universitaire); culture, sports, loisirs, divertissements + réparations																		1
34	Service de santé et service vétérinaire																		1
35	Institutions sans but lucratif; services domestiques																		1
36	Etat																		1
37	Assurances sociales																		1

Table 15. Translation key between NGAE and GEM-E3 sectors

Reparation is split into the different sectors, consistently with the splitting of intermediate consumption of reparation.

Re-aggregation into the GEM-E3 Compatible Consumption Categories

The aggregation in the 13 consumption categories is done according to the GEM-E3 classification, which is based on the OCDE ESA²⁷ functional classification COICOP²⁸. The detailed aggregation key is given below.

²⁷ ESA: European System of Accounts.

Final Consumption Categories of Households		Classification of the Consumption by Purpose												
No		1	2	3	4	5	6	7	8	9	10	11	12	13
1,1,1	Pain, farines et produits céréaliers	1												
1,1,2	Viande	1												
1,1,3	Poissons	1												
1,1,4	Lait, fromages, oeufs	1												
1,1,5	Huile et graisse	1												
1,1,6	Fruits et légumes	1												
1,1,7	Pommes de terre	1												
1,1,8	Sucre	1												
1,1,9	Café, thé, cacao	1												
1,1,10	Autres produits alimentaires	1												
1,2,1	Boissons non alcoolisées	1												
1,2,2	Boissons alcoolisées	1												
1,3	Nourriture fournie aux militaires	1												
1,4	Tabac	1												
2,1,1	Articles d'habillement		1											
2,1,2	Réparations des vêtements		1											
2,2,1	Chaussures		1											
2,2,2	Réparation de chaussures		1											
2,3	Vêtements fournis aux militaires		1											
3,1,1	Loyers implicites			1										
3,1,2	Loyers imputés			1										
3,1,3	Réparations			1										
3,2,1	Produits pétroliers				1									
3,2,2	Electricité				1									
3,2,3	Gaz				1									
3,2,4	Charbon				1									
3,2,5	Chaleur à distance				1									
3,2,6	Bois				1									
4,1	Meubles, accessoires fixes, tapis, revêtement					1								
4,2	Articles de ménage en textile, autres ameubl.					1								
4,3	Appareils de chauffage et de cuisine						1							
4,4	Verrerie, vaisselle, ustensiles de ménage					1								
4,5	Installation et réparation du logement					1								
4,6	Biens et services pour l'entretien de l'habit.					1								
4,7	Services domestiques					1								
5,1	Médicaments et autres produits pharm.							1						
5,3,1	Services des médecins, infirmières etc.							1						
5,3,2	Dentistes							1						
5,3,3	Laboratoire d'analyse							1						
5,3,4	Physiothérapeute							1						
5,3,5	Autres							1						
5,4	Soins des hôpitaux et assimilés							1						
5,5	Rémunération services d'ass.-accident							1						
6,1,1	Achats de voitures neuves								1					
6,1,2	Acquisitions nettes de voitures occasion								1					
6,1,3	Caravanes et mobilhomes								1					
6,1,4	Achats de motocycles								1					
6,1,5	Achats de vélomoteurs								1					
6,1,6	Achats de bicyclettes								1					
6,2,1	Accessoires, pièces de rechange									1				
6,2,2	Nettoyage et entretien									1				

²⁸ COICOP: Classification of Individual Consumption by Purpose.

Final Consumption Categories of Households		Classification of the Consumption by Purpose												
No		1	2	3	4	5	6	7	8	9	10	11	12	13
6,2,3	Services et réparations									1				
6,2,4	Achats courants et périodiques de combustibles									1				
6,2,5	Location de garage									1				
6,2,6	Leasing de véhicules									1				
6,2,7	Autres services									1				
6,3,1	Transports locaux et taxi										1			
6,3,2	Chemins de fer, bus de voyage										1			
6,3,3	Autres moyens de transport										1			
6,3,4	Autres services de transport										1			
6,3,5	Rémunération des services d'assurance									1				
6,4,1	Taxes de téléphone											1		
6,4,2	Taxes postales											1		
7,1,1	Appareil radio, télé, électrophones												1	
7,1,2	Matériel photo, inst musiques, bateaux et autres												1	
7,1,3	Autres articles récréatifs												1	
7,1,4	Pièces et accessoires et réparations												1	
7.2.1	Cinéma et théâtre												1	
7.2.2	Manifestations sportives												1	
7.2.3	Activités de sport et loisirs												1	
7.2.4	Taxes de concession TV, radio												1	
7.2.5	Location de TV et vidéo												1	
7.2.6	Location de radio et audio												1	
7.2.7	Location appareils photo et cinéma												1	
7.2.8	Location machines de bureau												1	
7.2.9	Location ordinateurs et PC												1	
7.2.10	Location cassettes vidéo												1	
7.2.11	Location objets de loisirs												1	
7.2.12	Services vétérinaires												1	
7.2.13	Autres services de loisirs												1	
7,3	Livres, articles de presse												1	
7,4	Taxe d'écolage												1	
8,1	Soins et effets personnels													1
8,2,1	Bijoux, montres, bagues, pierres précieuses													1
8,2,2	Autres articles personnels													1
8,2,3	Matériel de papeterie et dessins													1
8,3,1	Dépenses dans les restaurants et cafés													1
8,3,2	Dépenses d'hôtels et de services de log.													1
8,4	Voyages touristiques tout compris													1
8,5	Rémunération des services d'assurance													1
8,6	Services financiers, occasions, autres services													1

Table 16. Key for the aggregation of the final consumption categories of households into GEM-E3 consumption purposes

Appendix 3.4 Resulting SAM

IO TABLE CH90 GEM-E3																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT
1	1290		0	0	0	3	39	58	13	2	15	8471	175		3	8	2090	294	12462
2																			
3	70		818	13	21	43	115	348	44	34	79	160	261	32	535	24	592	173	3364
4	3		0	517	3	28	104	130	6	17	24	63	5	9	14	7	112	46	1090
5	139		7	34	1194	287	396	523	27	122	149	379	134	62	211	125	1195	230	5213
6	122		2	59	199	8055	389	186	2034	1915	3949	712	2091	21	170	19	390	418	20728
7	333		5	45	161	408	8591	929	639	180	818	1799	758	17	44	32	1715	645	17119
8	270		0	6	22	998	818	5929	687	255	942	1459	5371	273	426	388	6289	987	25122
9	46		1	22	76	158	119	119	2393	782	3176	235	659	173	136	113	2301	713	11220
10	113		1	18	66	167	193	222	373	2697	3070	229	432	54	330	27	558	1266	9816
11	159		2	40	142	324	312	341	2766	3479	6246	463	1091	227	467	140	2859	1979	21036
12	1365		1	4	14	217	564	411	893	616	1509	7448	2401	129	180	59	5469	1307	22586
13	560		2	105	349	117	107	213	121	170	291	981	1972	288	752	144	7011	2504	15687
14	24		1	12	43	104	293	165	256	153	409	333	377	1393	242	409	1963	614	6791
15	98		19	53	48	699	815	926	385	245	630	1563	829	432	2905	205	3236	712	13799
16	103		1	45	145	113	166	178	297	189	486	367	571	36	508	7281	6971	1315	18771
17	898		34	147	477	2237	3686	2832	3451	2519	5969	6575	6032	225	1922	2926	25163	5166	70258
18	33		1	13	43	58	169	55	62	70	132	173	99	13	72	48	1645	355	3040
TOT	5625		895	1134	3004	14016	16874	13562	14448	13444	27892	31410	23257	3382	8919	11956	69560	18725	278102

Table 17. Estimation of the 18x18 IO table in market prices

IO TABLE CH90 GEM-E3																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT
A	2093		35	141	1398	5202	5623	6388	5833	5944	11777	10134	17940	4947	10416	15041	55859	37911	196680
B	7021		26	380	3797	2584	3945	3493	2517	2400	4917	4235	6787	1868	3648	-796	51910	6631	105364
C						0	0	0	0	0	0	0	0	0	12166		-4	0	12162
D	66		1	6	62	56	136	95	124	45	169	1399	292	7	867	2176	616	225	6343
E	-1098				-34	2	7	2	3	4	7	-383	0	-8	-2900	9	-1147	0	-5536
F			1		20	348	86	406	283	799	1081	746	2300	113	47	-2	3644	0	9871
G	8082		62	528	5223	7843	9711	9978	8478	8393	16870	15385	25019	6814	12030	28596	107233	44767	315012
H	8082		62	528	5243	8192	9797	10384	8760	9191	17952	16130	27319	6928	12077	28594	110877	44767	324883
I	293		5	25	252	678	816	857	797	722	1519	1337	2769	808	1768	1982	7543	5938	28108
J	138101		471	2018	19962	101074	77868	112126	100187	109426	209613	204756	348094	68594	151708	175125	1159119	433818	3412059

Table 18. Estimation of sector specific value added and occupation

Notice that the social contributions of employers (included in A) are disaggregated and made available under letter I. Notice further that the sector specific full time job equivalents are available under letter J. Data on employment are taken from the SFSO, except for agriculture data that have been provided by the Swiss Farmers Association.

CONSUMPTION MATRIX (HH) CH90 GEM-E3														
	1	2	3	4	5	6	7	8	9	10	11	12	13	CFHH
1	3771											450		4221
2														
3				1189					2911					4100
4				1108										1108
5				2644										2644
6	21	55			621				104			51	6	858
7					559		1119		13			477	546	2715
8	14			23	400		19					2133	416	3006
9	4	21			238	336	1087		55			819	304	2864
10					20			1684	1160			299	6	3167
11	4	21			258	336	1087	1684	1215			1118	310	6031
12	19156	6878	167		3153		28		120			430	561	30493
13			667	43	231									941
14										267	2633	791		3691
15										2553			3047	5600
16							485		854				2305	3644
17	9996	3410	32515	267	3474	386	9502	1924	2549			6674	16816	87513
18		450			833		5667		10	40		1865	865	9730
TOT	32966	10835	33349	5275	9786	1058	18994	5291	8990	2860	2633	15107	25184	172327

Table 19. 18x13 households consumption matrix

CONSUMPTION MATRIX (OTHER) CH90 GEM-E3					
	CFNP	CFBK	CFGV	CFSI	CFOTH
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16		12162			12162
17				2982	2982
18	7259		43460		50719
TOT	7259	12162	43460	2982	65863

Table 20. Other final consumers consumption

Where:

- CFNP corresponds to non-profit organisations;
- CFBK corresponds to banks;
- CFGV corresponds to government; and
- CFSI corresponds to social insurance.

INVESTMENT MATRIX CH90																					
GEM-E3																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	HH	TOT	
1																					
2																					
3																					
4																					
5																					
6	45		0	1	17	41	60	69	25	36	61	101	62	84	185	133	637	665	955	3176	
7																					
8																					
9	150		2	1	23	178	255	325	125	112	238	400	297	534	449	310	1238	263	896	5795	
10	276		3	1	43	325	467	594	229	207	436	733	543	971	833	577	2317	571	1752	10878	
11	426		5	2	66	503	723	919	354	319	673	1132	840	1505	1282	887	3555	834	2649	16673	
12	48		0	1	24	35	53	56	18	40	58	95	49	41	227	166	841	1069	1439	4261	
13	390		3	10	196	284	434	452	148	328	476	774	398	338	1847	1347	6841	8699	11709	34675	
14																					
15																					
16																					
17	203		2	2	49	218	316	390	147	157	304	508	354	588	697	491	2147	1394	2430	10396	
18																					
TOT	1539		15	17	418	1584	2309	2805	1047	1199	2246	3742	2543	4061	5520	3910	17576	13495	21830	85854	

Table 21. Estimation of the 18x19 investment matrix in producer's prices

Notice that column 19 corresponds to the households (HH) investment, that is aggregated with column 17 in GEM-E3.

	Consumption			FIRMS	Exports	Tourist expenditure	Total Exports
	Labour	Capital	Total				
Transfers	0	0	0	0	0	0	0
Wages+SSC	0	0	0	0	0	0	0
Capital	0	0	0	0	0	-12162	0
Total Value Added	0	0	0	0	0	-12162	0
Actual Output	0	0	0	0	0	0	0
HHS	188690	40085	228775	0	51495	0	10040
FIRMS	0	57186	57186	-1548	0	0	0
Indirect Taxes	0	0	0	0	0	0	0
Direct Taxes	0	0	0	36981	0	0	18931
Social Security	0	0	0	53471	0	0	0
Subsidies	0	0	0	0	5536	0	0
VAT taxes	0	0	0	0	0	0	0
Duties	0	0	0	0	0	0	0
Gov. Foreign	0	0	0	0	0	0	0
Gov. firms	0	8092	8092	0	0	0	0
Total Taxes	0	8092	8092	90452	5536	0	18931
Distr. Output	0	0	0	0	0	0	0
EC	0	0	0	0	0	0	0
NON-EC	0	0	0	0	0	0	0
Imports	7990	0	7990	3092	1358	0	0
Expenditures abroad	0	0	0	0	0	0	0
Total Imports	7990	0	7990	3092	1358	0	0
SAVINGS	0	0	0	18288	36146	0	47970

Table 22. Transfers between macroeconomic agents

Notice that transfers between the macroeconomic agents have been drawn from the 1990 Swiss System of National Accounts. Transfers are generally introduced as 'net values', and the 'intra-agent' transfers are set to zero.

Consistency

Consistency of these data may be checked through adding data on import, export and stock variations, as illustrated in Table 23 below. One can verify that the elaborated SAM is calibrated, namely that the sum of rows and of lines are consistent, according to the double entry book-keeping concept:

National Expenditures

$$= \text{CINTG} + \text{CFHH} + \text{CFOTH} + \text{INVI} + \text{INVHH} + \text{STV} + \text{EXP}$$

$$= \text{IMP} + \text{CINTS} + \text{Va}_{\text{mp}}$$

Where:

- CINTG: intermediate consumption of a good;
- CFHH: final consumption of households;
- CFOTH: other final consumption;
- INVI: investment of industry (firms);
- INVHH: investment of households;
- STV: stock variations plus statistical deviations;
- EXP: exportation;
- IMP: importation;
- PINT: intermediate consumption of a sector;
- Va_{mp} : value added at market prices.

	Int. cons.	Final consumption			Investment		Stock var. & stat. err.	Export	NAT.	Import	DOM.	Int. cons.	Added	error
	Good	HH	OTH	Industry	HH				EXPND.		PRD.	sector	Value	
	CINTG	CFHH	CFOTH	INVI	INVHH		STV	EXP	ENAT	IMP	PDOM	CINTS	VA mp	
1	12462	4221						348	17031	3323	13708	5625	8082	0.14
2														
3	3364	4100						557	8022	7064	957	895	62	0.01
4	1090	1108					-90	12	2120	459	1661	1134	528	0.00
5	5213	2644						1365	9222	975	8248	3004	5244	
6	20728	858		2222	955		-87	6710	31386	9179	22208	14016	8192	0.54
7	17119	2715					329	18410	38572	11900	26672	16874	9797	0.30
8	25122	3006					45	2925	31099	7153	23946	13562	10384	0.13
9	11220	2864		4898	896		560	12902	33341	10132	23209	14448	8760	0.14
10	9816	3167		9126	1752		917	10080	34858	12223	22636	13444	9191	0.17
11	21036	6031		14024	2649		1477	22982	68199	22355	45844	27892	17952	0.31
12	22586	30493		2822	1439		325	10833	68498	20958	47540	31410	16130	0.26
13	15687	941		22966	11709		-205	361	51457	882	50575	23257	27319	-0.42
14	6791	3691						769	11251	942	10309	3382	6928	-0.03
15	13799	5600						4665	24065	3068	20996	8919	12077	0.05
16	18771	3644	12162					5979	40556	6	40549	11956	28594	-0.93
17	70258	87513	2982	7966	2430		528	16132	187810	7374	180435	69560	110875	-0.04
18	3040	9730	50719				-13	19	63495	5	63490	18725	44767	-0.96
TOT	278102	172327	65863	64024	21830		3786	115049	720981	117997	602984	278102	324883	-0.33

Table 23. Double entry book-keeping

Concluding Remarks

The presented results include:

- an estimation of the 18x18 I/O table in (intermediate demand) market prices;
- a disaggregation of the sector specific added value;
- an estimation of the consumption matrix in producer's (or supply market) prices;
- a matrix describing net transfers between economic agents;
- and an estimation of the 18x19 investment matrix in producer's prices including households investment.

These results have been elaborated on the basis of relatively (compared with EUROSTAT) poor data and were only possible with the kind support of the Laboratory of Applied Economics of the University of Geneva (LEA-UniGe), the Section of National Accounts of the Swiss Federal Statistical Office (SFSO) and the Institute for Business Cycle Research of the Swiss Federal Institute of Technology of Zurich (KOF-ETHZ).

Still, the quality of the obtained data is partially unsatisfactory. The main reasons are: i) the lack of certain statistics (e.g., on investment expenditures) and ii) the incompatibility of the Swiss nomenclature NGAE with the European nomenclatures (in particular the one used in GEM-E3). This implies that a significant amelioration of the obtained results could only be reached with a considerable amount of time and work.

Nevertheless, the goal has been reached in the sense that 'reasonable' data have been provided to complete the economic database of GEM-E3 Switzerland.

Additional sources for the economic database

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