GEMINI-E3 top-down CGE modeling for China and India in the global context (EPFL)

Introduction

GEMINI-E3 is the name of the first Computable General Equilibrium Model developed jointly by the French Ministry of Equipment and the French Atomic Energy Agency. The team now benefits from a nearly 15 years of experience in CGE modeling, associated with a close collaboration with the main research teams working in the field of climate change policy and with a participation to the political debate on this topic. The new version, which is the fifth in line, has been developed with the collaboration of the Swiss Federal Institute of Technology (Lausanne). GEMINI-E3 is currently a family of general equilibrium models, all of them multi-sector and dynamic, but some multi-country and some purely domestic or aimed at domestic policy assessment purposes[1]. The original version of the multi-country model is fully described in Bernard (1998). Several successive versions have been developed, with an increasing number of countries/regions (from 3 to 28) and an increasing number of sectors (from 8 to 18). A more detailed representation of countries and sectors was required by new types of appraisal, from very global ones such as the Kyoto Protocol to more precise ones such as the European Trading System implemented from the start of 2005. More precisely, the main and successive uses of the model have been directed toward:

- analyzing the implementation of economic instruments for greenhouse gases (GHG) emissions in a second-best setting (Bernard (2000));
- assessing the strategic allocation of greenhouse gases emission allowances in the EU-wide market (Bernard (2005));
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- assessing and comparing regional welfare costs associated with alternative multi-gas strategies for a stabilization of global greenhouse gases emissions in the long run (Bernard (2006b));
- analyzing the behavior of Russia in the Kyoto Protocol (Bernard (2002) , Bernard (2003);
- assessing the economic impact of the US withdrawal from the Kyoto Protocol (Bernard (2002b);
- analyzing the French Climate policy formulated under the Kyoto Protocol (Bernard (1999c, 1999b);
- assessing the cost of the Kyoto Protocol for Switzerland with and without international emissions trading (BernardCH);
- assessing the effects of the increase of oil prices on global and regional GHG (Viguier (2007)).

A clearer focus put on European climate change policies raised the question of the representation of the European Monetary Union, linking most of the members of the European Union, and of the way of taking into account the constraints of the single

[1] GEMINI-E3 France (Bernard (1999a) ,Bernard (1999b)), GEMINI-E3 Switzerland (Bernard et alii (2005)}, GEMINI-E3 Tunisia, (Besma (2006)).

currency and the spillover effects of domestic policies. Effectively, as long as the policies were roughly similar among European countries, which means that they also responded in a similar way, there was no need to take explicitly into account the mechanisms of the monetary union. This is not anymore the case when purely domestic policies or significantly differing policies are contemplated. This is the reason why a new version of the model, GEMINI-EMU, has been developed along these lines. The two versions have most in common and the following technical description, specific to GEMINI-E3, is also largely valid for GEMINI-EMU. Differences between the two models will be presented in section~\ref{emu}: though they may appear very limited, they have sweeping effects on policy implementation and efficiency.

As for numerical specification and resolution, the present version of GEMINI-E3 (and GEMINI-EMU) is formulated as a mixed complementarity problem using GAMS with the PATH solver (Ferris (2000), Ferris (1997)).

Structure of the model

As most CGE models, GEMINI-E3 simulates all relevant markets, domestic and international, considered as perfectly competitive, which implies that the corresponding prices are flexible: markets for commodities (through relative prices), for labor (through wages), for domestic and international savings (through rates of interest and exchange rates[2]. Time periods are linked in the model through endogenous real rates of interest determined through the balancing of savings and investment. National and regional models are linked by endogenous real exchange rates resulting from constraints on foreign trade deficits or surpluses. There is one notable -and usual- exception to this general assumption of perfect competition, which concerns foreign trade. Goods of the same sector produced by the different countries are not supposed to be perfectly competitive. They are considered as economically different goods, more or less substitutable according to an elasticity of substitution known as Armington's (Armington assumption, (Armington 1969)). A high value means a high degree of competition in the world market, a low value a small degree of competition. This assumption is justified by the high level of aggregation in the nomenclature of goods: agricultural production in developed countries has little in common with agricultural production in developing countries, and significant differences also exist among developed countries and among developing countries. It is also inescapable because, without this assumption, the countries would specialize, each in one sector or a very limited number of sectors[3]. This treatment of foreign trade will be detailed further below. Compared to other CGE models, GEMINI-E3 has two main specificities:

- a comprehensive and detailed representation of indirect taxation. Indirect taxation and social contributions rates are differentiated by commodity (taxes on production, on imports), by sector (social contributions, subsidies), by sector x commodity (intermediate consumption), by commodity x institutional sector (final demand), and by commodity x sector x IS (investment);
- the focus put on the measurement of the welfare cost of policies, and its analysis by main components, either domestic or international.

[2] The real exchange rate between two countries is the relative price of the numéraires chosen in each country (and usually based on a basket of goods representative of GDP.

[3] This is a side-effect of the general assumption of constant returns to scale in production (with the exception of agriculture and fossil fuels)

Time periods are linked in the model through endogenous real rates of interest determined by equilibrium between savings and investment. National and regional models are linked by endogenous real exchange rates resulting from constraints on foreign trade deficits or surpluses.

gives an overall description and the main characteristics of the model. The main outputs of the GEMINI-E3 model are by country and annually: carbon taxes, marginal abatement costs and prices of tradable permits (when relevant), effective abatement of CO2 emissions, net sales of tradable permits (when relevant), total net welfare loss and components (net loss from terms of trade, pure deadweight loss of taxation, net purchases of tradable permits when relevant), macro-economic aggregates (e.g. production, imports and final demand), real exchange rates and real interest rates, and data at the industry-level (e.g. change in production and in factors of production, prices of goods).

Table-1: Dimensions of the GEMINI-E3 model

Countries or Regions		Sectors
Annex B		***Energy***
Germany	DEU	01 Coal
France	FRA	02 Crude Oil
United Kingdom	GBR	03 Natural Gas
Italy	ITA	04 Refined Petroleum
Spain	ESP	05 Electricity
Netherlands	NLD	***Non-Energy***
Belgium	BEL	06 Agriculture
Poland	POL	07 Forestry
Rest of EU-25	OEU	08 Mineral Products
Switzerland	CHE	09 Chemical Rubber Plastic
Other European Countries	XEU	10 Metal and metal products
United States of America	USA	11 Paper Products Publishing
Canada	CAN	12 Transport n.e.c.
Australia and New Zealand	AUZ	13 Sea Transport
Japan	JAP	14 Air Transport
Russia	RUS	15 Consuming goods
Rest of Former Soviet Union	XSU	16 Equipment goods
Non-Annex B		17 Services
China	CHI	18 Dwellings
Brazil	BRA	
India	IND	***Household Sector***
Mexico	MEX	
Venezuela	VEN	***Primary Factors***
Rest of Latin America	LAT	Labor
Turkey	TUR	Capital
Rest of Asia	ASI	Energy
Middle East	MID	Fixed factor (sector 01-03)
Tunisia	TUN	Other inputs
Rest of Africa	AFR	

The nomenclature that has been chosen allows one to individualize the main economic countries/regions and GHG emitters. Table-2 gives for the countries and the regions represented in the model their shares in the world population and the world GDP, and in the global GHG emissions. Except the two biggest economies (US and Japan) and the two highest emitters (US and China), no country or region has a bigger than 10% share either in the world economy or in the GHG emissions.

Table-2: Countries and regions represented in GEMINI-E3 - Structural Data in 2001

Countries or regions	Population[a]	GHG emissions[b]	GDP[c]	%Pop.	%GHG	%GDP
DEU	82.3	310	1 889	1.4%	3.2%	6.0%
FRA	59.3	160	1 347	1.0%	1.6%	4.3%
GBR	58.7	205	1 427	1.0%	2.1%	4.5%
ITA	57.7	157	1 113	1.0%	1.6%	3.5%
ESP	40.7	107	583	0.7%	1.1%	1.9%
NLD	15.9	105	400	0.3%	1.1%	1.3%
BEL	10.3	54	240	0.2%	0.6%	0.8%
POL	38.6	102	178	0.6%	1.0%	0.6%
OEU	88.4	250	1 190	1.5%	2.6%	3.8%
CHE	7.2	15	236	0.1%	0.2%	0.8%
USA	284.2	1938	10 335	4.7%	19.9%	32.8%
JAP	127.0	376	4 159	2.1%	3.9%	13.2%
XEU	55.8	130	326	0.9%	1.3%	1.0%
CAN	30.7	479	711	0.5%	4.9%	2.3%
AUZ	22.9	186	417	0.4%	1.9%	1.3%
TUR	68.2	90	153	1.1%	0.9%	0.5%
RUS	146.6	489	300	2.4%	5.0%	1.0%
XSU	120.6	327	106	2.0%	3.4%	0.3%
CHI	1274.0	1278	1 293	21.0%	13.1%	4.1%
IND	1021.1	429	463	16.8%	4.4%	1.5%
ASI	957.5	793	1 473	15.8%	8.1%	4.7%
BRA	173.9	244	497	2.9%	2.5%	1.6%
VEN	24.4	94	128	0.4%	1.0%	0.4%
LAT	224.6	322	735	3.7%	3.3%	2.3%
MEX	100.1	170	611	1.6%	1.7%	1.9%
MID	167.9	347	636	2.8%	3.6%	2.0%
TUN	9.6	34	20	0.2%	0.3%	0.1%
AFR	802.9	550	520	13.2%	5.6%	1.7%
World	6071.0	9742	31 488	100.0%	100.0%	100.0%

[a] million of inhabitants

[b] million tonnes of carbon-equivalent

[c] billion 2001 US$ using exchanges rates

The Chinese and Indian version of GEMINI-E3

Within the TOCSIN project a special attention have been done to build a new version of GEMINI-E3 for China and India. This work has been done in cooperation with our Chinese and Indian partners and two documents describe in detail the procedure used have been written. The first step of this work was to build two new Social Accounting Matrix (SAM) for China and India.

The structure of a SAM in GEMINI-E3

- The SAM used in the GEMINI-E3 model takes into account three agents (or institutions): households, government and abroad (or rest of the world). Note that firms in GEMINI-E3 are not considered as an agent, even if the production accounts are described for the 18 sectors, because we suppose that firms are owned by households who received the remuneration of capital and the rents of fix factors.

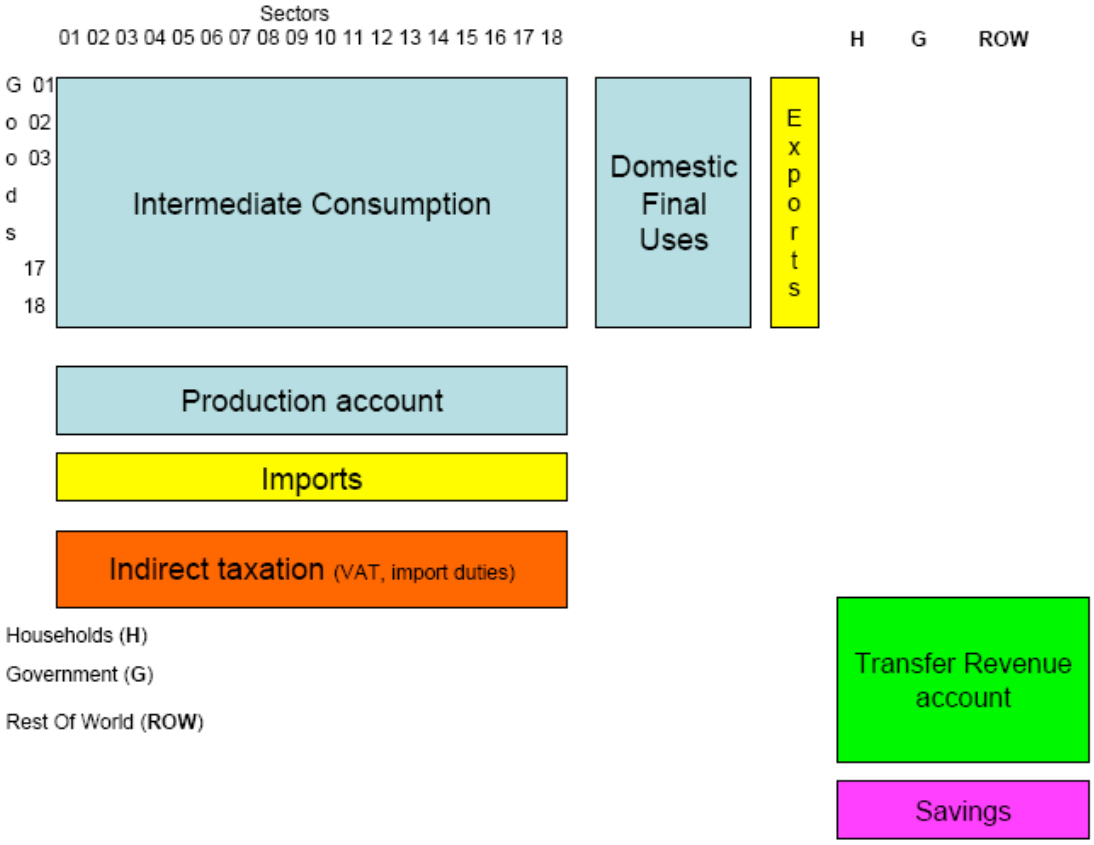

Figure-1: Social Accounting Matrix

Figure-1 presents the general structure of the SAM used in GEMINI-E3. This SAM is constituted of six blocks:

- An intermediate consumption matrix, which gives for each sector the intermediate consumption in the 18 goods;

- A domestic final uses block, which describes the households consumption, the government consumption and the investment in the 18 goods;
- An external trade block, which gives the imports and exports;
- An indirect taxation block which describes the taxes collected on household consumption, on value added components (social security contribution on labor, tax on operating surplus), on external trade (imports duties and export subsidies), on intermediate consumption, etc.
- A transfer revenue matrix, which describes the transfer of revenue between agents (household, government and foreign (or ROW));
- finally, a saving block which computes the saving of each agent which the sum is equal to the total investment.

SAM for China and India

The data used to build the two SAMs have been based on national accounts:

- The original I/O table for China is from 2002-year I/O Table of China, which is for 122x122 sectors and calculated by Producer Price (in 10,000 RMB);
- The original Input-Output table for India is from the government of India for the year 1998-1999. The Input-Output table is available for 115 x 115 sectors, the units are in Rupees Lakh (1 Lakh = 100,000).

The final SAM are presented in Figures 2 and 3. The SAMs are completed by several other data on:

- Energy balances;
- Population;
- Non carbon greenhouse gas emissions and related abatement cost.

Calibration

The next step is to calibrate the model, for the stylized parameters that are the elasticities we used the default values that are reported in Table-3.

Table-3: GEMINI-E3 India and China Default Parameters

Parameter	Sector	Value	Parameter	Sector	Value
σ	All	0.30	σ_r	All	0.60
σ_{pf}	All	0.20	σ_m	All	0.20
σ_{pp}	All	0.10	σ_x	01,03	2.00
σ_e	01 to 05	0.10		02	10.00
	06,07,12,13,14	0.20		05	0.50
	Others	0.40		12,13,14,17	0.10
σ_{ef}	01 to 04	0.10		18	0.05
	05	1.50		Others	3.00
	06 to 11 & 15 to 18	0.90	σ_{mm}	All	0.20
	Others	0.30			

Figure-2 and Figure-3 show the complete SAMs of China and India.

	Coal	Oil	Gas	Petroleum Products	Electricity	Agriculture	Forestry	Mineral Products	Chemicals, Rubber, Plastic	Metal and Metal products	Paper products publishing	Transport nec	Sea Transport	Air Transport	Construction goods	Equipment goods	Services	Dwellings	Total	Investment	Household Consumption	Government consumption	Export	Total Uses
Coal	173.8	0.2	158.4	1554.4	597.6	133.3	96.3	6987.4	3327.3	321.4	818.4	85.4	0.5	0.2	3.7	0.2	18.4	0.2	96825	0	4246	0	3005	13332.1
Oil	0	823.1	92.7	2465.5	118.2	0.1	0	30.5	670.6	29	3	15.2	0.7	0.2	0.4	10.6	69.2	0.1	2955.89	0	0.0	0	72.4	26313.1
Gas	0	292.9	403.2	76.1	485	0.1	0	30.5	670.6	29	3	15.2	0.7	0.2	0.4	10.6	69.2	0.1	2044.6	0	403.0	0	5.1	2478.6
Petroleum Products	304.7	647.2	640	137.42.9	4104.5	3729.2	263.9	29831.9	7530.2	7324.4	1618.3	1554.8	8567.5	2745.5	1034.9	1644.4	4710.9	0.1	6027.95.5	0	6207.5	0	3223.3	71.8222.3
Electricity	1901.1	1096.7	447.3	3073.1	4303.6	2488.8	199.3	4011.7	8380.2	6864.5	1554.8	690.5	8.9	16.3	30.8	1004.67.4	4294.6	0.1	6027.95.2	0	6742.9	0	403	61.941.1
Agriculture	77.8	0	0	2.7	2.8	50355.7	217	4164.4	5067.5	0.2	271.2	902.1	27	30.8	0	3303.1	1228.43	13.9	1771.05.9	13619.5	6742.9	5.1	7.30.4	1.27.386.5
Forestry	561.2	0	0.2	11.6	19.8	771.6	1987.1	1197.4	45.45.6	4.7.5	50.2.0	11.6	0.2	0.2	0.2	3266.3	1339.3	310.0	1815.4.5	0	6924.4	0.4	1016	19419.4
Mineral Products	1716.7	6.9	5.8	1.08.8	425.5	653.5	70.1	1.57.3.2	8.127.4	2.156.2	331.4	1.75.5	0.2	0.1	0.2	2.03.4.7	1.753.2.5	3.63.1.7.4	46.8.9	0	3.67.5.7	10.4	3.10.7.3	21.0.7.2.1
Chemicals, Rubber, Plastic	4.80.2	1.51.9	2.1.8	1.93.1	1.40.5	2.0.0.3.2	7.6.1	9.0.7.1	2.1.0.5.1	3.2.4.9.0	4.1.5.0	2.0.0.7	1.6.1	0.5	0.3	8.1.1.7.1.3	2.0.3.7.4	3.6.1.1	1.3.6.8.6.4	2.4.6.1.0	3.0.1.4	3.6.4	2.1.0.7.3	1.6.8.9.6.8.9
Metal and Metal products	6.6.2.6	2.1.8.6	1.0.1.3	2.4.1.0.3	1.0.7.6	1.4.2.0.0.5	6.3.5.2	1.0.7.4.5	4.2.0.6.0	1.0.1.5.2.3	5.0.1.5	1.0.2.2	0.6	0.3	0.4	1.4.6.4	6.1.6.9	0.4	2.4.1.6.1.0	0	1.3.1.0.4	0.4	2.1.0.7.2.1	1.6.8.9.6.8.9
Paper products publishing	1.6.8.5	2.0.5	0.8	3.6.2	4.1.5	3.3.2.1	3.4.5	3.0.1.0.3	3.2.4.9.0	9.4.5.6	1.5.4.9.6.6	4.0.5.0.9	5.7.1	0.5	0.3	1.4.6.4	6.1.6.9	0.4	2.4.1.6.1.0	0	1.3.1.0.4	0.4	2.1.0.7.2.1	1.6.8.9.6.8.9
Transport nec	2.1.6.6	9.6.7	2.1.1	1.0.0.7.7	1.9.0.7.6	3.1.6.0.8	3.1.9.7	6.4.7.0.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3	1.6.0.2.2.9	1.0.3.2.3
Sea Transport	0.1	4.8	0.2	1.8.2	1.0.4	3.8.8	1.8	4.7.0.2	1.5.0.7.5	3.4.4	2.0.1.2	1.0.4.5.1	1.1.0.7.3	1.9.1	1.4.6.4	4.4.2.5.4	1.0.6.9.9	1.4.6.4.2	1.0.8.2.2	1.0.4.5.6	1.1.9.2	3.2.6	1.0.3.2.4	2.3.2.0.6
Air Transport	0.2	2.6	0.2	6.4	1.5.4	3.8.8	1.8	7.2.1	3.2.4.5	3.4.4	2.0.1.2	1.0.4.5.1	1.1.0.7.3	1.9.1	1.4.6.4	4.4.2.5.4	1.0.6.9.9	1.4.6.4.2	1.0.8.2.2	1.0.4.5.6	1.1.9.2	3.2.6	1.0.3.2.4	2.3.2.0.6
Construction goods	1.0.5.4.7	1.4.9.2	1.7.0	2.6.2.0.6	2.6.7.4.6	1.4.2.0.0.6	7.0.4.7	1.9.0.3.8.5	1.7.5.6.3.9	9.6.6.1.0.8	6.3.0.4.0	1.1.0.8.8.2.1	2.1.2.4.3.6	3.1.4.0.3	1.7.2.3.3	2.2.0.0.0.1	1.1.7.0.6.4.1	1.2.9.4.0	1.1.7.0.6.4.1	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Equipment goods	1.0.5.1	7.0.1.3	8.1	2.6.2.0.6	3.9.6.2.4	6.6.7.4.6	1.0.0.2.1	1.9.0.3.8.5	1.7.5.6.3.9	9.6.6.1.0.8	6.3.0.4.0	1.1.0.8.8.2.1	2.1.2.4.3.6	3.1.4.0.3	1.7.2.3.3	2.2.0.0.0.1	1.1.7.0.6.4.1	1.2.9.4.0	1.1.7.0.6.4.1	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Services	1.0.5.1	6.1.1.3	7.0.6	3.9.6.2.4	6.6.7.4.6	1.4.2.0.0.6	7.0.4.7	1.9.0.3.8.5	1.7.5.6.3.9	9.6.6.1.0.8	6.3.0.4.0	1.1.0.8.8.2.1	2.1.2.4.3.6	3.1.4.0.3	1.7.2.3.3	2.2.0.0.0.1	1.1.7.0.6.4.1	1.2.9.4.0	1.1.7.0.6.4.1	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Dwellings	0.6	6.9	0.2	1.9.4.4	6.4	1.4.2.0.0.6	7.0.4.7	1.9.0.3.8.5	1.7.5.6.3.9	9.6.6.1.0.8	6.3.0.4.0	1.1.0.8.8.2.1	2.1.2.4.3.6	3.1.4.0.3	1.7.2.3.3	2.2.0.0.0.1	1.1.7.0.6.4.1	1.2.9.4.0	1.1.7.0.6.4.1	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Total	1.6.8.7.2	2.4.8.3.2	1.9.1.5.7	2.4.1.0.3.0	2.4.1.0.3.0	1.0.1.0.5.3.0	1.1.1.4.0.2	2.1.0.7.4.5.0	2.7.1.5.6.0.9.0	1.9.4.1.6.4.0	2.7.1.5.6.0.9.0	1.0.3.2.3.0.7.0	2.3.2.0.6.0.0	2.8.4.1.0.1.0	3.8.1.0.7.4.0	1.6.0.2.7.8.0.0	1.4.9.1.0.3.4.0	1.0.8.4.2.0.0	1.4.9.1.0.3.4.0	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Tax on Intermediate consumption	2.1.5.1.0.0	1.2.8.7.1.0	9.1.4.0	3.4.1.0.3.0	6.7.7.0.1.0	1.7.6.9.1.3	1.1.1.4.0.2	2.1.0.7.4.5.0	2.7.1.5.6.0.9.0	1.9.4.1.6.4.0	2.7.1.5.6.0.9.0	1.0.3.2.3.0.7.0	2.3.2.0.6.0.0	2.8.4.1.0.1.0	3.8.1.0.7.4.0	1.6.0.2.7.8.0.0	1.4.9.1.0.3.4.0	1.0.8.4.2.0.0	1.4.9.1.0.3.4.0	0	1.3.1.9.0	0.4	1.6.4.0.5.7	1.6.4.0.5.7
Coal	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	7.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Agriculture	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals, Rubber, Plastic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metal and Metal products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paper products publishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transport nec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sea Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction goods	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment goods	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dwellings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0.00	0.00	3.60	0.00	-76.20	0.00	0.00	-0.2	-0.2	-0.3	0.00	-396.50	0.00	-7.8	0.00	-0.2	0.00	0.00	-55.4	0	0.0	0	9.1	-55.4
Taxes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-317.90	0.00	0.00	0.00	0.00	0.00	0	0.0	0	0.0	0
Tax on Investment	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	24.4	0	0.0	0	34.4	0.3
Tax on Government consumption	0	0	0	0	0	0	0	0	0	0	0	0.8	0	-0.5	0	0	0	0.1	0.1	0	0.0	0	0.3	0.3
Tax on factor																							10.1	
Property	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labor	0	0	0	0	0	2.9	0	59.4	12.4	1.6	14.1	418.3	40.3	76.4	78.7	78.7	643.9	99.6	91.6	19367				
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Import	327.6	7143.2	231.3	5658.3	443.6	16330.3	178.9	5488.3	4.134.3	2.122.4	7658.9	5.101.8	1.107.5	3390.7	5803.6	9.1.6.0.3.2	4.6.8.8.1.5.4	0	3.8.1.4.1.2.4					
Import Margins	66	466.3	1.2	462.6	0	872.1	170.2	1.372.9	2.2.6.8	1.1.9.4.6	9.9.7.6	0	0	0	0	3.1.1.0.4	2.6.4.7.3	0	1.4.2.2.5.6					
Import Duties	3.7	0	-1.1.3.2.4.3.8.5.-1.4	3.8.1.6	0	4.3.6.4	5.5	5.3.3.2	4.9.4.5.2	0	5.5.8.5	0	0	0	0	1.6.8.1.0.2	-5.4	0	3.3.5.3.5					
Export Subsidies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Total Resources	1.3.2.7.2.0	2.6.3.3.1.0	2.4.7.8.6.0	7.1.6.2.3.0	6.1.6.4.1.1.0	3.2.7.3.8.5.0	1.9.4.1.9.4.0	2.1.0.7.2.1.1.0	2.7.1.5.6.0.9.0	1.0.1.6.8.3.0.0	6.9.6.6.4.3.0	1.4.6.9.3.0.7.0	2.3.2.0.6.0.0.0	2.8.4.1.0.1.0.0	5.9.0.2.1.0.4.0	1.9.4.1.6.4.0.0	1.0.9.7.8.4.3.0	2.6.4.9.7.2.0.0	3.9.7.9.3.0.0.0					
Check Balance	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%					

Households					
Government	0	58304			
Foreign					
Expenditure		691308	1.68.583	49.3.9.7.9	1.1.2.9.5.1.1
SAVINGS		4.6.1.2.0.3	9.2.7.2.5	-9.7.0.9.0	2.5.9.8.7.7
					3.9.6.6.3.8
					4.5.0.0.2.8

Figure-2: SAM for China

	Coal	Oil	Gas	Petroleum Products	Electricity	Agriculture	Forestry	Mineral Products	Chemical, rubber, Plastic	Metal and Metal products	Paper products publishing	Transport nec	Sea Transport	Air Transport	Consuming goods	Equipment goods	Services	Dwellings	Total	Investment	Household Consumption	nt consumption	Export	Total Uses
Coal	21	0	1	0	4287	0	0	428	146	194	71	3	0	0	56	32	70	0	5308	0	761	0	44	6114
Oil	0	0	0	14640	1	0	0	0	1	0	0	0	0	0	0	0	0	0	14642	0	0	0	0	14642
Gas	0	0	0	0	814	12	0	19	1006	34	12	0	0	0	20	49	19	0	1984	0	47	0	0	2031
Petroleum Products	0	0	0	2741	452	1	0	417	3092	532	40	4823	1089	371	500	324	141	0	14822	0	12066	0	1208	27796
Electricity	1	0	0	0	3867	7335	17	1174	2952	2953	1044	689	137	46	1529	3355	4593	0	29692	0	6628	0	13	36334
Agriculture	0	0	0	9	0	15410	0	13	1482	0	104	267	45	11	24012	161	5693	0	47209	560	88753	420	3166	140107
Forestry	0	16	12	1	0	9	18	19	95	4	113	0	0	0	1139	291	345	0	2081	0	3229	0	39	5400
Mineral Products	98	19	13	4	0	1	0	1639	469	1045	25	35	6	1	275	525	8039	0	12197	10	251	0	2234	14691
Chemical, rubber, Plastic	152	0	0	171	79	6963	12	469	11090	297	526	1662	282	69	4343	3319	6921	0	38356	1750	5724	512	6394	50735
Metal and Metal products	0	0	0	12	0	13	0	67	240	4231	66	0	0	0	215	17502	1784	0	24131	341	0	0	2175	26647
Paper products publishing	9	14	10	4	123	12	10	14	717	20	1614	311	50	12	734	297	1309	0	5281	0	2512	557	317	8647
Transport nec	182	2	1	367	2347	1720	79	726	1285	1080	308	1313	213	52	3739	1561	7109	0	22082	1410	20996	1165	2149	47802
Sea Transport	25	1	0	38	153	257	10	65	178	65	38	185	30	7	598	185	943	0	2781	215	3353	169	1610	8128
Air Transport	9	0	0	13	52	88	3	22	61	22	13	63	10	3	204	63	321	0	946	73	1141	57	698	2916
Consuming goods	54	62	44	20	7	1078	5	251	764	89	202	101	14	3	11583	980	4846	0	20106	134	54829	190	18761	93520
Equipment goods	419	80	57	70	1740	281	44	219	593	968	100	2610	293	71	1044	7364	10960	0	28914	38165	8539	3585	14562	91565
Services	255	0	0	1107	3998	4740	218	1129	4303	2628	780	9211	1297	316	13635	9297	32518	1282	88712	56859	81782	46248	10063	281663
Dwelings	0	234	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400	0	18934	0	0	19333
Total	1224	428	305	19198	17919	37921	418	6871	28474	14163	5055	21272	3465	963	63628	45307	85613	1282	353305	99517	309114	52903	63232	878071
Fix Factor	1338	835	450	0	0	42430	344	172	0	0	0	0	0	0	0	0	0	0	45570					
Social Security	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0					
Labor	841	665	376	191	5815	36722	1947	1097	2523	832	855	14235	1951	475	13416	6384	96749	1070	188143					
Capital	1473	1167	647	543	12387	18378	1946	2502	6941	2609	943	8637	1217	296	7036	10157	80478	16344	178701					
Value Added	3652	2668	1474	734	18202	97530	4237	3771	11463	3441	1798	22872	3168	772	20451	16540	177228	17414	407414					
Indirect tax	39	525	251	0	79	-1355	4	1384	243	2510	470	29	24	6	1637	4757	1699	0	12306					
Tax on intermediate consumption																								
Coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Petroleum Products	0	0	0	0	53	0	0	154	1142	196	15	1781	402	137	185	117	46	0	4226					
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Mineral Products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Chemical, rubber, Plastic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Metal and Metal products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Paper products publishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Transport nec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Sea Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Air Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Consuming goods	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Equipment goods	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Dwelings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Total	0	0	0	0	53	0	0	154	1142	196	15	1781	402	137	185	117	46	0	4226					
TVA	0	0	0	0	0	2986	111	8	193	0	84	706	113	38	1828	287	2751	637	9742					
Assices	0	0	0	6099	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6099					
Tax on investment	0	0	0	0	0	45	0	1	140	27	0	113	17	6	11	3055	4551	0	7966					
Tax on Government consumptio	0	0	0	0	0	9	0	0	11	0	12	25	4	1	4	76	987	0	1129					
Tax on factor																								
Fix Factor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Labor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Capital	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Import	697	9058	1	1372	80	2188	522	2074	6479	4555	908	1004	935	994	3403	16593	8789	0	59651					
Import Margins	140	562	0	142	0	181	67	190	445	169	98	0	0	0	277	370	0	0	2643					
Import Duties	361	1401	0	251	0	602	40	438	2145	1586	207	0	0	0	2097	4463	0	0	13591					
Export subsidies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
Total Ressources	6114	14642	2031	27796	36334	140107	5400	14691	50735	26647	8647	47802	8128	2916	93520	91565	281663	19333	878071					
Households																						38675		446289
Government																					14602			69659
Foreign																								62295
Expenditure																					323716	91778	63232	
SAVINGS																					122573	-22119	-937	99516 saving less invest
																				rate of saving for House	28.39%			
																				rate of saving nation	24.66%			

Figure-3: SAM for India

Baseline

We have built a first baseline scenario with the GEMINI-E3 China and India model. The aim of this tentative baseline is to test and validate the model and check a first set of results. Note that in the simulations presented in other chapters we used more relevant assumptions taking into account feedbacks from the partners of the TOCSIN project and especially our partners from China and India. The tables 6 and 7 give the macroeconomic result of this tentative baseline. Figure 4 gives the energy consumption.

Table-4: Macroeconomic Results in Million 2001 US Dollar – Tentative Baseline - China

	2001	2010	a.a.p.c.	2020	a.a.p.c.	2030	a.a.p.c.	2040	a.a.p.c.	2050	a.a.p.c.
GDP	1 294 328	2 572 294	7,9%	4 480 133	5,7%	7 333 435	5,1%	11 286 330	4,4%	16 225 434	3,7%
Imports	359 337	539 514	4,6%	731 953	3,1%	979 502	3,0%	1 266 817	2,6%	1 581 210	2,2%
Consumption	601 962	1 158 648	7,5%	2 001 280	5,6%	3 257 111	5,0%	5 000 711	4,4%	7 185 589	3,7%
Government Con.	165 893	329 676	7,9%	574 066	5,7%	939 656	5,1%	1 446 120	4,4%	2 079 199	3,7%
Investment	456 290	940 812	8,4%	1 536 784	5,0%	2 430 856	4,7%	3 621 010	4,1%	5 020 256	3,3%
exports	429 521	682 671	5,3%	1 099 957	4,9%	1 685 315	4,4%	2 485 306	4,0%	3 521 600	3,5%

Table-5 : Macroeconomic Results in Million 2001 US Dollar - Tentative Baseline - India

	2001	2010	a.a.p.c.	2020	a.a.p.c.	2030	a.a.p.c.	2040	a.a.p.c.	2050	a.a.p.c.
GDP	463 642	805 473	6,3%	1 348 988	5,3%	2 200 569	5,0%	3 416 805	4,5%	5 052 229	4,0%
IMP	76 009	107 624	3,9%	148 542	3,3%	201 059	3,1%	263 171	2,7%	335 085	2,4%
CONS	309 294	523 882	6,0%	872 185	5,2%	1 410 679	4,9%	2 184 033	4,5%	3 224 217	4,0%
GCVTOT	60 786	105 579	6,3%	176 796	5,3%	288 429	5,0%	447 756	4,5%	661 965	4,0%
INV	106 069	179 846	6,0%	287 017	4,8%	452 490	4,7%	677 294	4,1%	969 625	3,7%
EXP	63 502	103 791	5,6%	161 532	4,5%	250 031	4,5%	370 893	4,0%	531 508	3,7%

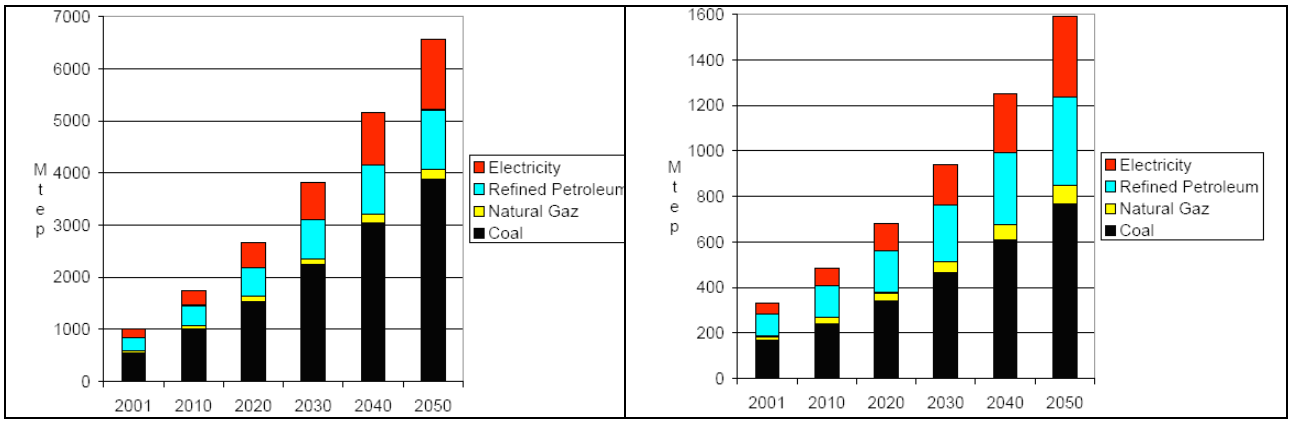

Figure-4: Energy consumption by Fuel in Mtoe, China (left) India (right), Tentative Baseline

Carbon tax scenarios

In order to test the GEMINI-E3 China and India models we have run several carbon tax scenarios. In these scenarios we suppose that a uniform GHG tax is implemented in India. We tax not only CO_2 but also the other greenhouse gases (i.e. methane, nitrous oxide and fluorinated gases). The receipt of the tax is redistributed by government to their citizens through a lump sum transfer. We have tested different level of taxes: 1$, 2$, 5$, 10$, 20$.. 100$, 120$, .. 500$. Figure-5 and Figure-6 show the GHG emissions abatement in respect to the level of the GHG tax for the year 2050.

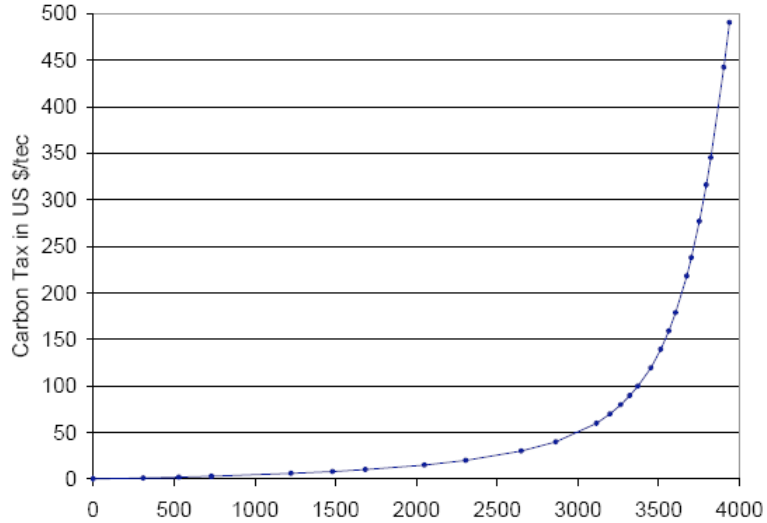

Figure-5: Carbon tax and GHG emissions in 2050 - China

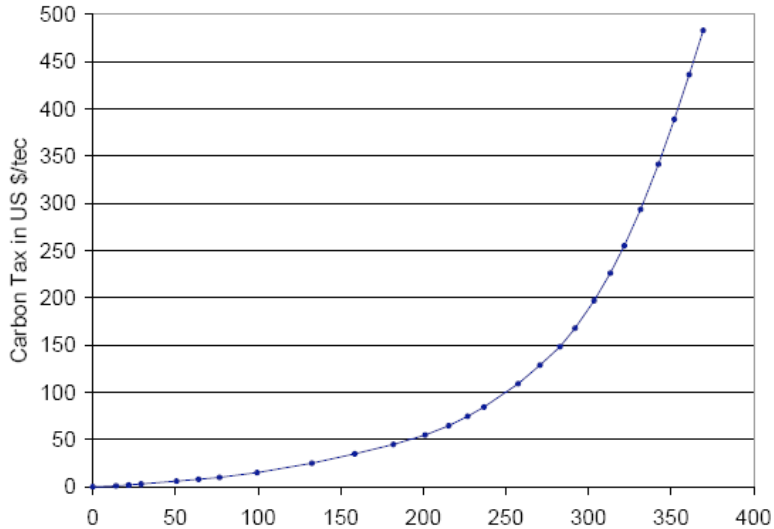

Figure-6: Carbon tax and GHG emissions in 2050 - India

After these different steps and tests, the two models for China and India were integrated in the full version and used for the several simulations done with the GEMINI-E3 model.