Modeling Climate Change Adaptation in GEMINI-E3

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www.reme.epfl.ch
Outline

1. Description of the project

2. The GEMINI-E3 model

3. Work done
   - Sectoral classification
   - Agriculture
   - Tourism
   - Electricity
   - Other sectors

4. Next steps
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Objective of the project

- Simulate the impacts of climate change without/with adaptation in the agriculture, energy, infrastructure and tourism sectors for Switzerland
- Analyze and quantify the adaptation to climate change
- Assess the general equilibrium effects within the economy of climate change impacts
- Evaluate the gains coming from adaptation measures financed by the government
- Determine the amount of government financing plan necessary to adaptation
Implementation of adaptation in GEMINI-E3 for Switzerland

- Build an aggregated version of GEMINI-E3 in respect to regions
- Desaggregate sectors analyzed in this project
- Bibliographic research on climate change impacts and adaptation behaviors for these sectors ← Database built by REME (EPFL)
- Modeling climate change impacts and adaptation for these sectors

Simulation of climate change impacts without/with adaptation

- BAU scenario
- Climate change policies
- If necessary run stochastic analysis on parameters linked to adaptation
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Main Characteristics

- World computable general equilibrium model
- Fifth version
- Dedicated to the analysis of climate change & energy policies
- 28 regions (including Switzerland)
- 5 energy sectors
- 13 non-energy sectors
- All GHG Emissions (EMF 21)
- Database GTAP 6 (2001)
- gemini-e3.epfl.ch
Existing Studies

- More than 30 Studies
- More than 20 publications in scientific journals
- Participation to the EU FP6 TOCSIN Projet and EU FP7 PLANETS Project
- Regular Participation to the Energy Modeling Forum (Stanford University)
- Representative Studies:
  - Assess the Swiss post-Kyoto climate policy (BAFU Grant)
  - Analyse the European Energy-Climate Directive (EMF22 Working group)
  - Assessment of the carbon tax required to achieve the french climate target (Centre d’Analyse Stratégique Grant)
  - Climate change effects of high oil prices
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A new classification concerning sector and goods

- **Target**: Desaggregate sectors linked to agriculture, energy, infrastructure and tourism for Switzerland
- **Constraints**: national accounts
- **We have used two sources**: Swiss Input Output Table (SIOT) build by INFRAS and the GTAP 6 Database
- **These two sources concern the year 2001**
- **In the next months we plan to use the new GTAP 7 database (2004) and the new SIOT**
Existing Classification

**Energy Sectors**
- 01 Coal
- 02 Crude Oil
- 03 Natural Gas
- 04 Refined Petroleum
- 05 Electricity

**Other sectors**
- 06 Agriculture
- 07 Forestry
- 08 Mineral Products
- 09 Chemical Rubber Plastic
- 10 Metal and metal products
- 11 Paper Products Publishing
- 12 Transport n.e.c.
- 13 Sea Transport
- 14 Air Transport
- 15 Consuming goods
- 16 Equipment goods
- 17 Services
- 18 Dwellings
Climate change costs for the most impacted sectors (years 2030, 2050, 2070 and 2100)

Source: Ecoplan/SigmaPlan, 2007
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Agriculture - Existing information

Agricultural sectors

1. Paddy rice
2. Wheat
3. Cereal grains n.e.c.
4. Vegetables, fruit, nuts
5. Oil seeds
6. Sugar cane, sugar beet
7. Plant-based fibers
8. Crops n.e.c.
9. Cattle, sheep, goats, horses
10. Animal products n.e.c.
11. Raw milk
12. Wool, silk-worm cocoons
13. Forestry
14. Fishing

- One sector in the SIOT
- 14 sectors in the GTAP database
Agriculture - Value added by sector

In Millions US $ (Source: GTAP 6)
Agriculture - Proposed classification

**Agricultural sectors**

1. Paddy rice
2. Wheat
3. Cereal grains n.e.c.
4. Vegetables, fruit, nuts
5. Oil seeds
6. Sugar cane, sugar beet
7. Plant-based fibers
8. Crops nec
9. Cattle, sheep, goats, horses
10. Animal products n.e.c.
11. Raw milk
12. Wool, silk-worm cocoons
13. Forestry
14. Fishing

**Proposed classification**

1. Raw milk
2. Animal products
3. Vegetables, fruits and nuts
4. Other Agricultural products
5. Forestry

**P. Calanca Proposition**

1. Wheat and Cereal grains n.e.c.
2. Oil seeds
3. Sugar cane, sugar beet
4. Crops nec
5. Bovine products
6. Other Animal products
7. Raw milk
8. Other products
9. Forestry
Crops sensitivity to climate change

Variables of interests: mean and inter-annual variability of crop yields

- All crops (maize, winter wheat, winter canola)$^a$
  - negative impacts due to higher temperatures
  - positive impacts due to CO$_2$ fertilization
- Summer crop (maize)$^a$
  - Negative impacts due to less precipitations

Adaptation measures

Three classes of adaptation measures

- Crops and varieties choice
- Cultural techniques
- Farm management

All crops (winter/summer)

- Slower maturing cultivars
- Shifts in sowing date
- Diversifying crops

Summer crops

- Irrigation
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Special features

- No tourism sector per se in the SIOT nor in the GTAP database
- Need to be built from the existing sectors
- Sectors with direct tourism revenues: Accommodation and catering, passenger transport (rail, road, water and air transport), retailing, recreational, cultural and sporting activities, health, service activities.
9 related sectors in the SIOT

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G55</td>
<td>Hotels and restaurants</td>
</tr>
<tr>
<td>G60b</td>
<td>Rail passenger transport</td>
</tr>
<tr>
<td>G61</td>
<td>Water transport</td>
</tr>
<tr>
<td>G62</td>
<td>Air transport</td>
</tr>
<tr>
<td>G60e</td>
<td>Road commercial passenger transport</td>
</tr>
<tr>
<td>G63c</td>
<td>Other transport help, support and intermediaries</td>
</tr>
<tr>
<td>G85</td>
<td>Health and social work</td>
</tr>
<tr>
<td>G91</td>
<td>Activities of membership organizations n.e.c.</td>
</tr>
<tr>
<td>G92</td>
<td>Recreational, cultural and sporting activities</td>
</tr>
</tbody>
</table>
Information available from FSO for the year 2001 and 2005 (Satellitenkonto Tourismus):

- Total receipts (direct tourism expenditures) in 2001: 30.2 B CHF
- Share attributable to tourists from abroad (41.8%)
- Expenditures from tourists in several sectors (cf. next slide)
Tourism demand by products

Tourists consumption of different goods and services
(Source: FSO, Satellitenkonto Tourismus, 2008)
Tourism demand by categories of visitors

Tourism consumption according to five visitors types
(Source: FSO, Satellitenkonto Tourismus, 2008)
Climate change impacts

- Impacts: mainly through deteriorated snow conditions for winter tourism
- The net effect of climate changes should be negative
Adaptation measures

- To mitigate the impacts of deteriorating snow conditions
  - Snowmaking facilities
  - Improvements in ski area preparation and maintenance
  - Ski area expansion towards higher location resp. northern oriented mountainside
  - Diversifying tourism offer

- Focus on snowmaking investments
  - Already implemented: 33% of the total prepared ski slopes area in 2008 (SBS 2008)
  - Substantial use of resources: 18 Mio cubic meters water used during the 2007/08 winter season (SBS 2008)
  - Federal and cantonal support through the LIM law since the mid-nineties (granted amounts can be found in Gonseth (2008)).
**Proposed classification**

1. Winter overnight tourism for CH and ROE (Rest Of Europe)
2. One-day winter tourism for CH and ROE
3. Summer tourism for CH and ROE
4. Trip outside Europe (import sector)
Arborescence - Proposed nested utility function
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Sensibility to climate change

1 Supply
   - Less or more precipitation ?, more evaporation → Hydro generation
   - Constraint on cooling of thermal power plants (nuclear)
   - Wind Storms on Infrastructures (electricity network)

2 Demand
   - Air Conditionning → Demand increase
   - Less severe winter → Less heat demand

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\(^1\)Climate change and hydropower production in Swiss Alps: quantification of potential impacts and related modelling uncertainties, *Hydrol Earth Syst. Sci.*, 2007

\(^2\)Th. Frank, "Climate change impacts on building heating and cooling energy demand in Switzerland", *Energy and Buildings*, 2005.

Modeling power generation

Production

Material
Labor
Capital
Generation

Fossil Energy

Hydraulic

Renewable

Nuclear

Coal

Oil

Natural gas

Capital
Fuel
Water
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Other sectors

New sectors described

12a  Rail infrastructure
12b  Rail passenger transport
12c  Rail goods transport
12d  Other public transport
12e  Road commercial passenger transport
12f  Road goods transport
12g  Road goods own transport
12h  Pipeline
17a  Hotels and restaurants
17b  Water transport infrastructure
17c  Air transport infrastructure
17d  Road infrastructure
17e  Other transport n.e.c.
17f  Activities of membership organizations n.e.c.
       Recreational, cultural and sporting activities
17g  Insurance and pension funding
17h  Health and social work
### Share of production

<table>
<thead>
<tr>
<th>Other sectors</th>
<th>Climate sensitive sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Electricity</td>
</tr>
<tr>
<td>Oil</td>
<td>Raw milk</td>
</tr>
<tr>
<td>gas</td>
<td>Animal products</td>
</tr>
<tr>
<td>Petroleum Products</td>
<td>Vegetables fruits, nuts</td>
</tr>
<tr>
<td>Mineral product</td>
<td>Other Agricultural products</td>
</tr>
<tr>
<td>Chemical</td>
<td>Forestry</td>
</tr>
<tr>
<td>Metal and Metal products</td>
<td>Hotel Restaurant</td>
</tr>
<tr>
<td>Paper products publishing</td>
<td>Activities of membership organizations</td>
</tr>
<tr>
<td>Rail infrastructure</td>
<td>Insurance and pension funding</td>
</tr>
<tr>
<td>Rail passenger transport</td>
<td>Health and social work</td>
</tr>
<tr>
<td>Rail goods transport</td>
<td>Tourism</td>
</tr>
<tr>
<td>Other public transport</td>
<td>Total</td>
</tr>
<tr>
<td>Water transport</td>
<td>17.7%</td>
</tr>
<tr>
<td>Water transport infrastructure</td>
<td></td>
</tr>
<tr>
<td>Air transport</td>
<td></td>
</tr>
<tr>
<td>Air transport infrastructure</td>
<td></td>
</tr>
<tr>
<td>Road infrastructure</td>
<td></td>
</tr>
<tr>
<td>Road personal passenger transport</td>
<td></td>
</tr>
<tr>
<td>Road goods transport</td>
<td></td>
</tr>
<tr>
<td>Road goods own transport</td>
<td></td>
</tr>
<tr>
<td>Pipeline</td>
<td></td>
</tr>
<tr>
<td>Transport n.e.c.</td>
<td></td>
</tr>
<tr>
<td>Consumption goods</td>
<td></td>
</tr>
<tr>
<td>Equipment Goods</td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td></td>
</tr>
</tbody>
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Gosele, Matasa, Thalmann, Viele Modeling Climate Change Adaptation in GEMINI-E3
Next steps...

- Validate our propositions
- Build the Social Accounting Matrix
- Finalize the specifications
- Create the new version of GEMINI-E3