ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Adaptation decisions and damage costs under uncertainty in an empirical general equilibrium framework

Takafumi Usui*

*Laboratory of Environmental and Urban Economics, EPFL

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[2] Since this is a on-going research, please do not circle it.

This is a joint project with Philippe Thalmann (EPFL) and Frank Vöhringer (EPFL and Econability).

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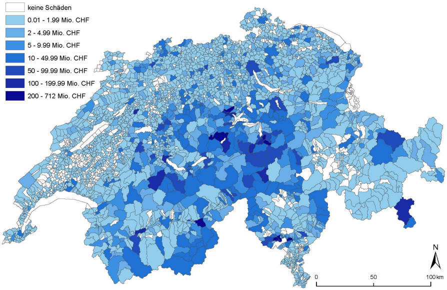
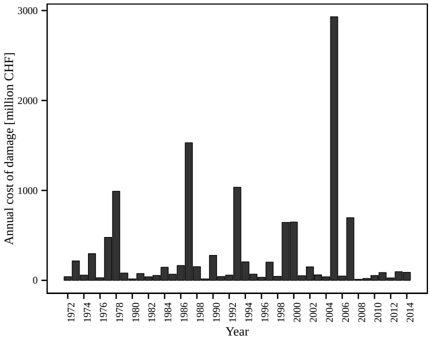
Cost of flood damages in Switzerland



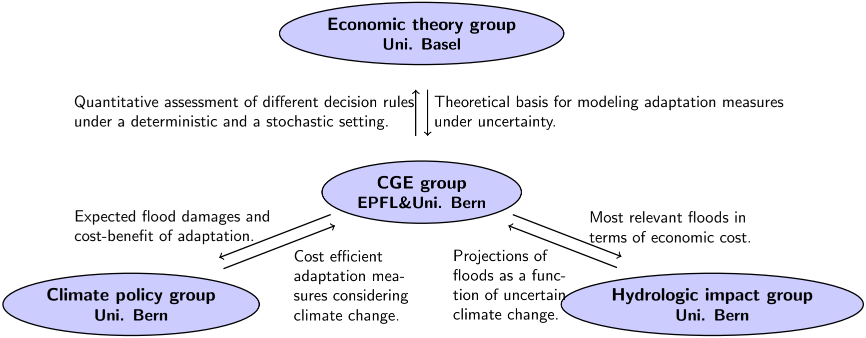
(a) Spatial distribution of costs



(b) Annual damage costs

Source: WSL Storm Damage Database of Switzerland

Interdisciplinary collaborations



Research objectives of my thisis

- To show how uncertainty can be implemented on a CGE model.
- To gain a better understanding of the economic characteristic of different adaptation measures for flooding as a function of ambiguous climate change.
- To model behaviorally plausible decision-making processes for flood events.
- To define efficient adaptation measures for selected flood events in Switzerland and to analyze how the benefits of adaptation and the costs of expected damage can be developed.

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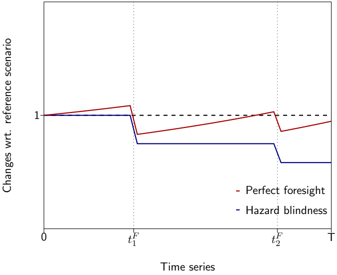
Perfect foresight and hazard blindness

- Perfect foresight is not applicable if uncertain external shocks are involved.
- Some adjustments are necessary since no economic agent can expect future shocks precisely.



Assumptions of hazard blindness:

- Perfect foresight for macroeconomic conditions.
- Uncertain about future external shocks.
- The time scale is divided before and after the shocks and the model is recalibrated with the damaged economy.

Subjective probability and individual learning

There is a general observation that we tend to:

- forget flood experiences by not experiencing the next floods (forgetting-by-not-experiencing); and
- become more anxious for the next floods because of accumulated flood experiences (alerted-by-experiencing).

By assuming an exponential function and multiplying two, we represent the subjective probabilities for a decision-maker:

$$p_t^f = \overline{r}^f \left(t - \hat{t}^f\right)^{-c} \left(n_t^f + 1\right)^d$$

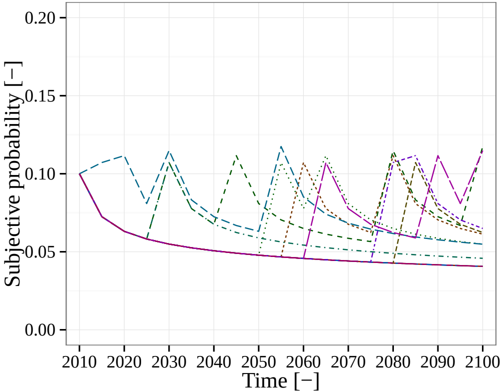
where, p_t^f is the subjective probability of the flood f, $\overline{r}^f$ is a reciprocal of the return periods of the target flood, $\hat{t}^f$ is the last flooded time period and n_t^f is the number of experienced floods up to the period t.

Scientific learning can be modeled in the same way to elicit more rigorous subjective probabilities.

Difficulty:

How to calibrate the coefficient parameter c and d?

10 simulation runs for subjective probability



Preliminary parameters:

- Poisson rate $\lambda = 0.10$.
- $c = 0.20$ and $d = 0.10$

Investment decisions and expected damage on capital stock

- Investment decisions are made taking into account expected damage on capital stock.
- If there is no flood, $z_t = 0$. We have expected damage $p_t^f \phi_{s,t}^f$ on K_t.
- If flood occurs, $z_t = 1$. We will experience full scale damage on K_t.

$$K_{s,t+1} = (1-\delta)\left[1 - \left(p_t^f\right)^{1-z_t} \cdot \phi_{s,t}^f\right] K_{s,t} + I_{s,t}$$

where, $K_{s,t}$ is accumulated capital stock in the sector s, $I_{s,t}$ is investment, δ indicates depreciation rate, $K_{s,t}^{AF}$ is accumulated capital stock after flood damage and $\phi_{s,t}^f$ is a proportional damage scale.

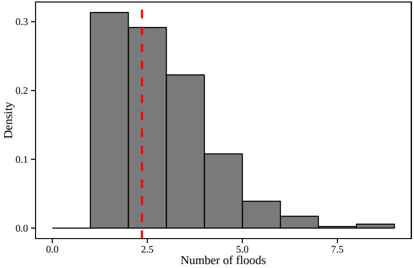
Note:

$\phi_{s,t}^f \sim \text{LogNorm}\,(0.05, 0.05)$ and constant over time as well as sectors. We will somehow calibrate time- and sectoral-dependent damage parameters.

Poisson flood events and a log-normal damage scale

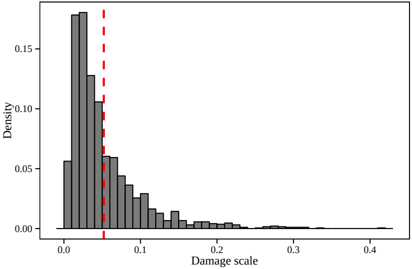
Dynamic distribution of events

- Poisson flood events (Barro, 2006).
- Focus on 50 years flood.
- Poisson rate: $\lambda = 0.10$.



Damage scale

- Log-normal distributed damage scale (Merz et al., 2004).
- Numerical sample of mean: $\mu = 0.05$; variance: $\sigma^2 = 0.05$.



GENESwIS and planned extensions

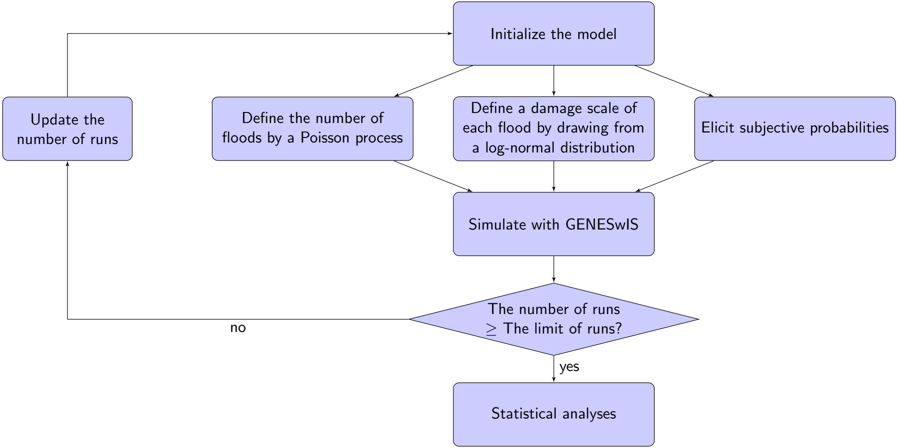
GENESwIS

- GENESwIS is a fully dynamic CGE model for Switzerland (Vöhringer, 2012).
- Calibrate based on the Swiss IOT in 2008.
- Flexible sectoral aggregations and a putty-clay capital accumulation.
- Widely employed for climate policy simulations.

Planned extensions

- Modify to create a version with hazard blindness.
- Introduce uncertain flood events modeled by a Poisson process and a log-normal distribution.
- Investment decision-making based on elicited subjective probabilities.
- Model several adaptation measures.

Simulation algorithm

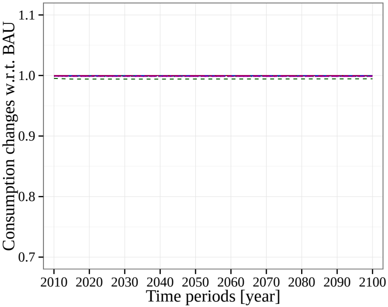


Note:

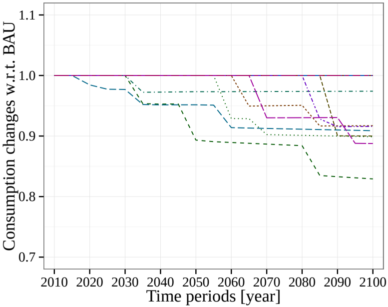
- Target flood has 50-years return period. We can have several floods in parallel.
- Agent behavior is either perfect foresight or hazard blind.

Preliminary results: consumption

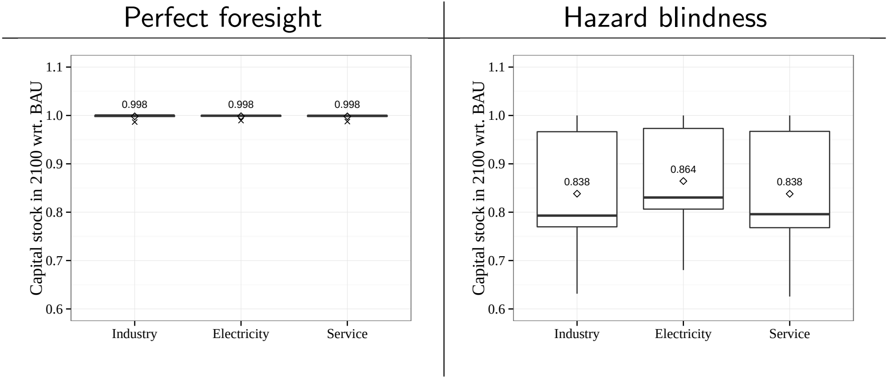
Perfect foresight



Hazard blindness



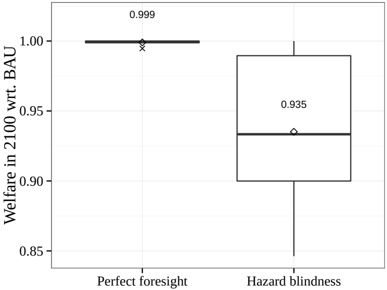
Sectoral capital stock in the year 2100



Note:

Putty-clay assumption: 12 domestic production sectors are aggregated into 3 sectors (Industry, Electricity and Service).

Aggregated welfare



Short summary of preliminary results

- Hazard blind assumption.
- Implement:
  i) Subjective probability.
  ii) Poisson flood events and a log-normal distributed damage scale parameters.

  on the GENESwIS model.
- Hazard blind agent will suffer more from future flood hazards than a perfect foresight agent.
- Adaptation to floods is necessary.

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Adaptation capital

- To abate expected damage by flooding on existing capital stock.
- Economic characteristics of adaptation capital (cost and benefit).

Planned methodology:
A damage scale parameter ψ_t is a monotone decreasing function of an original damage scale parameter ϕ_t:

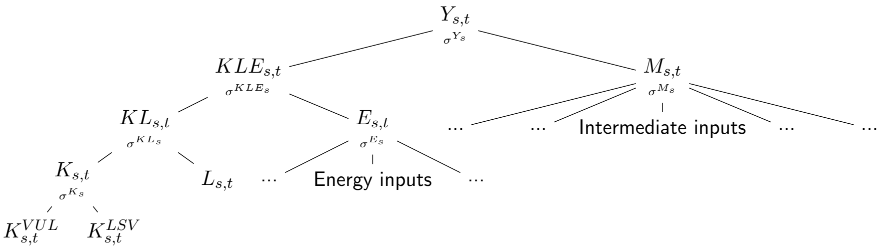
$$\psi_t = \phi_t \exp\left(\frac{-\theta A_t}{K_t}\right)$$

cf., Bosello et al. (2010) considered three types of adaptations and aggregated them based on a two stages CES tree. Climate change damage with adaptation $CCDA_{n,t}$ is:

$$CCDA_{n,t} = \frac{1}{1 + ADAPT_{n,t}} CCD_{n,t}$$

Spatial planning adaptation

- Design an economy less vulnerable to flood by spatial planning.
- Decompose capital stock into flood vulnerable ($K_{s,t}^{VUL}$) and less vulnerable ($K_{s,t}^{LSV}$) one.
- Vulnerable capital is more productive but at higher risk.
- What is the incentives to invest to less vulnerable over vulnerable capital?



Risk attitude for climate change

- How to link climate change discussions and risk attitudes foc climate change Prospect theory?
- Well-observed bounded rational behaviors in climate change issues might be modeled by applying Prospect theory.

Risk attitude for climate change	Prospect theory
Risk-loving in a loss domain Risk-averse in a gain domain	Value function $V(x_i)$
Overweigh rare events Underweigh frequent events	Weighting function $w^+,\ w^-$

Question:

What is the dynamic reference point? Status quo?

Contents

For efficient programming

- Toy model:
  Small scale model with stylized data. Large-scale model, especially developed by your co-workers, is sometimes a black-box at first.
- GAMS and MPSGE:
  High-level modeling language for optimization and equilibrium analyses; MPSGE is the subsystem of GAMS and is designed to offer stylized programming environment for CGE modeling.
- Emacs + gams-mode:
  Classical but still extensible and customizable text editor; Shiro Takeda develops a macro for GAMS programming.
- R + ess-mode:
  Powerful language for statistical analyses and graphics; `gdxrrw` bridges GAMS and R by converting a GDX file.
- git + magit:
  Version control system; Easy to handle several branches within a same directory; Easy to collaborate with your co-workers.

Bibliographies

Barro, Robert J (2006) "Rare disasters and asset markets in the twentieth century," *Quarterly Journal of Economics*, Vol. 121, No. 3, pp. 823–866, DOI: `http://dx.doi.org/10.1162/qjec.121.3.823`.

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