General equilibrium simulations of floods

Philippe Thalmann

Sinergia-CCAdapt Workshop

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Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Structure of the presentation

- Context
- Models
- 4 steps towards modelling the economic costs of floods with adaptation
- Special emphasis on adaptation under uncertainty with bounded rationality
- Research in Gunter Stephan's group
- Expected results

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Project "Costs of climate change impacts"

- Contract with FOEN for 2014-2016
- Based on existing literature and research, including our own previous projects on CC impacts and adaptation
- Gaps in the literature identified, in particular **the lack of monetary assessment of impacts**
- Enhance integrative CGE modelling framework (GEMINI-E3) and perform simulations
- In depth analysis of costs of floods with adaptation in this Sinergia project

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

The two models

- "Theory with numbers" ("toy model")
  - close to theoretical models, with stylized data
  - high flexibility
- GENESwIS
  - fully dynamic CGE calibrated to Swiss input output table
  - open economy (CH) including taxes and GHG emissions
  - simulates interaction of inter-temporally optimizing agents (firms, households) and government
  - flexible prices and quantities
  - substitutability of consumption goods & inputs to production governed by nested CES utility and production functions

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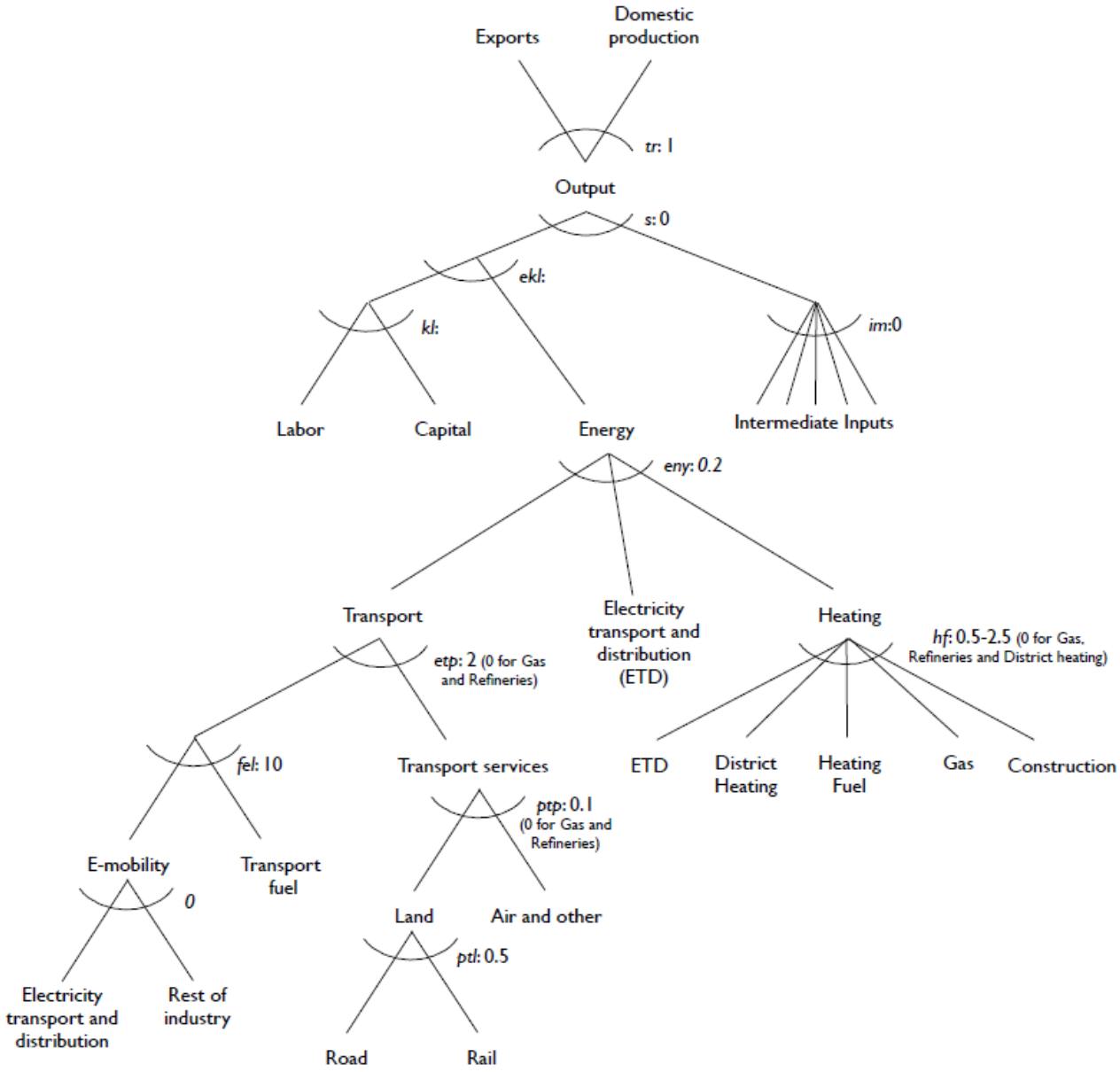
ENAC IA LEURE
philippe.thalmann@epfl.ch

GENESwIS: sectoral production (NCES)



Four steps

1. Improve knowledge about flood damages
2. Introduce floods into the simulation models
3. Incorporate adaptation measures into the models
4. Try alternative decision-making rules for adaptation

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Step 1

1. Improve knowledge about flood damages
   - use inputs from "impacts" group
   - select historical flood events
   - assess related damages (WSL database)
   - learn about possible adaptation measures
   - develop dynamic damage projection methods for the selected types of events
   - project damage costs until 2100

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Floods selected for economic simulations

Priority	Year/ month	Most affected		Magnitude	Return period	CH impact Mio. CHF	Information
		Catchments	Cantons				
1.	1999 May	Thur Aare Linthkanal Bodensee	ZH, BE	1129 m^3/s 613 m^3/s	> 150 > 150	751	Extensive damage, different from 2005 in terms of process and affected region.
2.	2000 Oct	Lago Maggiore	VS, TS			777	A lake case; differs from other floods w.r.t. adaptation measures and spatial development.
1.	2005 Aug	Aare Reuss	BU, UR	605 m^3/s 523 m^3/s	> 150 30	3109	The largest historical event in terms of damages.
2.	2007 Aug	Birse Aare	JU, BE	383 m^3/s 524 m^3/s	> 150 62	722	Processes similar to 2005. How has adaptive behaviour reduced costs relative to 2005?
2.	2011 Oct	Kander Lötschental	BE, VS, GL	65 m^3/s 120 m^3/s	>100 30-100	118	This particular process may increase in frequency due to climate change.

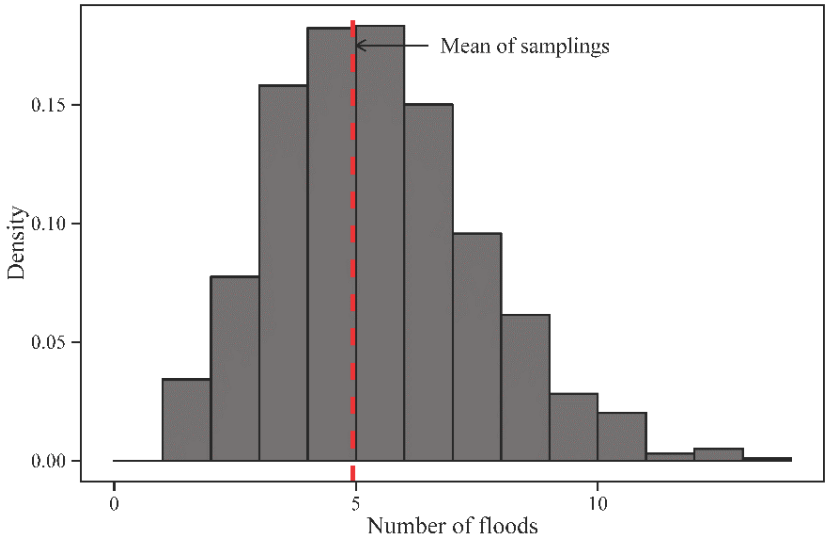
Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

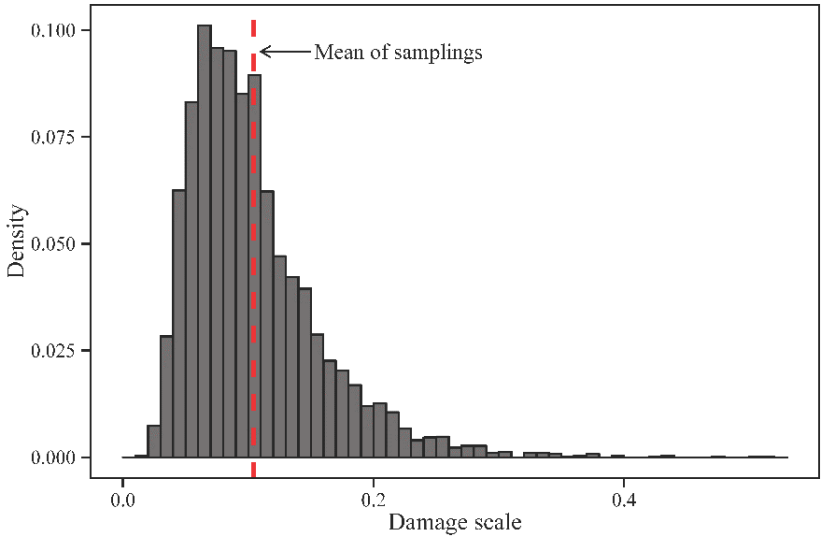
Step 2

2. Introduce floods into the simulation models

- unanticipated stochastic shocks
- destruction of capital (more/less vulnerable locations)
- direct impact on welfare (e.g. non-market damages)
- toy model:

  Poisson flood event distribution & log-normal distributed damage scale

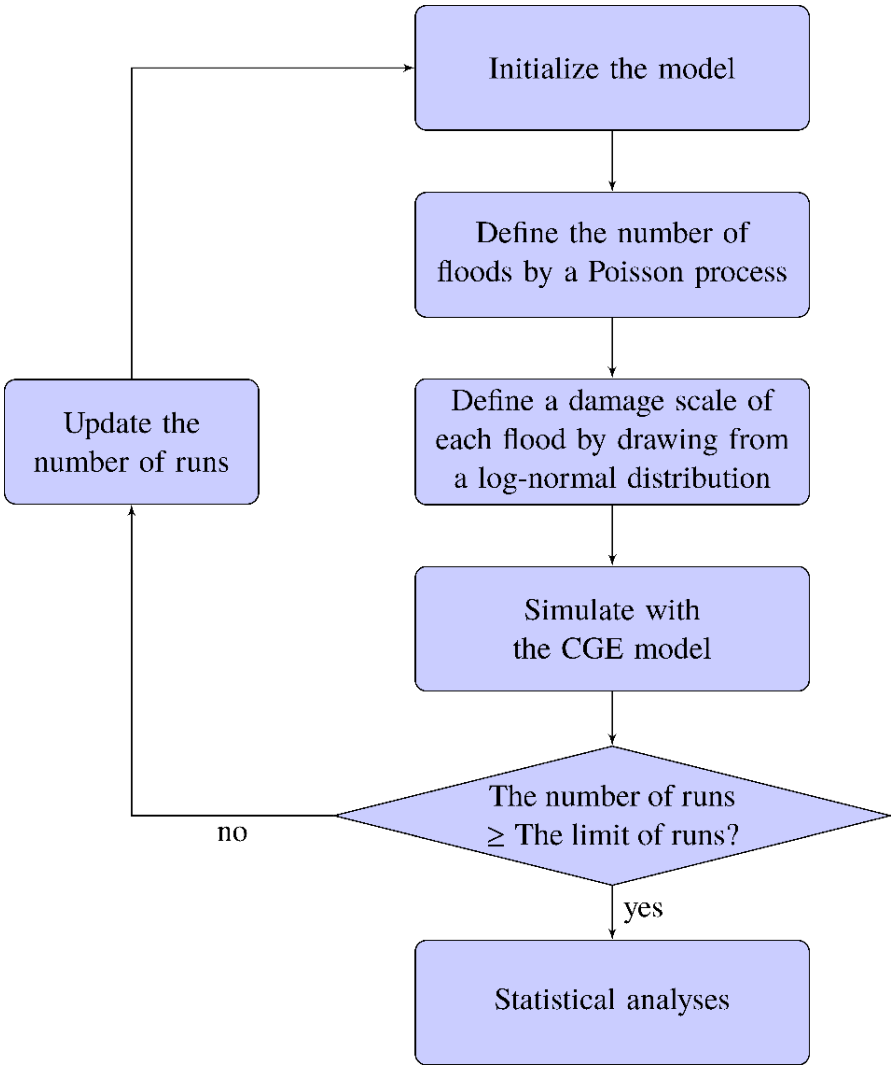




Step 2

- Perfect foresight, but not concerning the timing and magnitude of flood events
- The model needs to be re-initialized after each unanticipated flood
- Evaluating individual flood scenarios as well as Monte Carlo simulations

Simulation algorithm



Step 3

3. Incorporate adaptation measures in the model

- types of measures
  - (infra-)structural, e.g. protection capital, alarm systems
  - spatial planning, e.g. building in less vulnerable locations
  - environmental information
- private and public adaptation
  - private: structure of the economy adapts to shocks
  - public: investment into adaptation capital & spatial planning
- costs and benefits of adaptation
  - cost function: total costs and input shares
  - crude estimates of related damage reduction benefits

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Step 4

4. Try alternative decision-making rules for adaptation
   - use insights from the "theory" and "policy" groups
   - autonomous adaptation by optimising economic agents
     - depends on their anticipations
   - proactive vs. reactive public adaptation according to decision rules
     - reference: optimal decision-making under uncertainty
     - descriptive: sub-optimal decision-making, e.g. heuristics
     - prescriptive: how to improve public decision-making on adaptation?

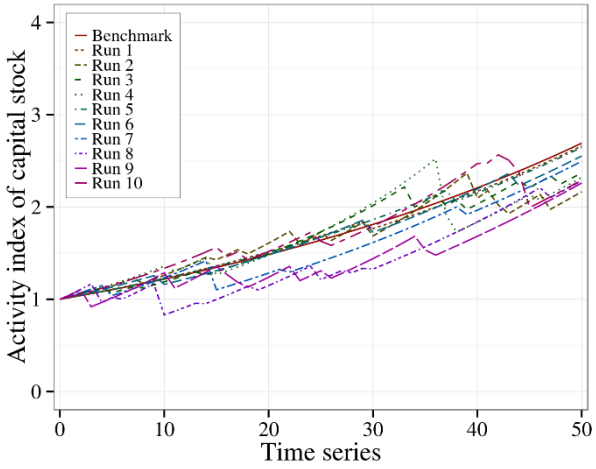
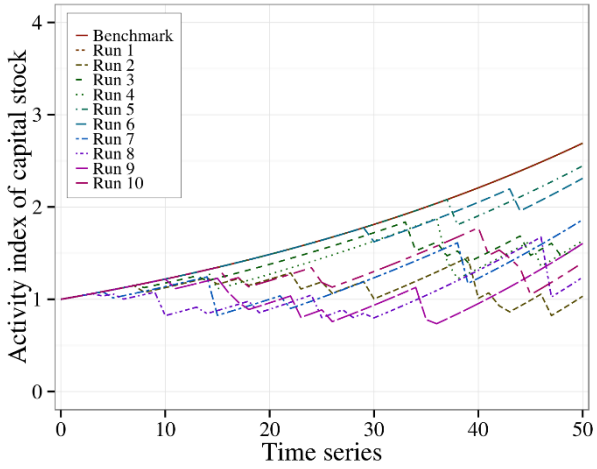
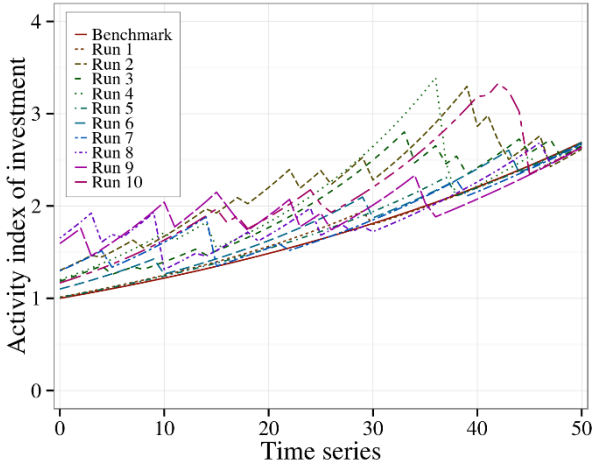
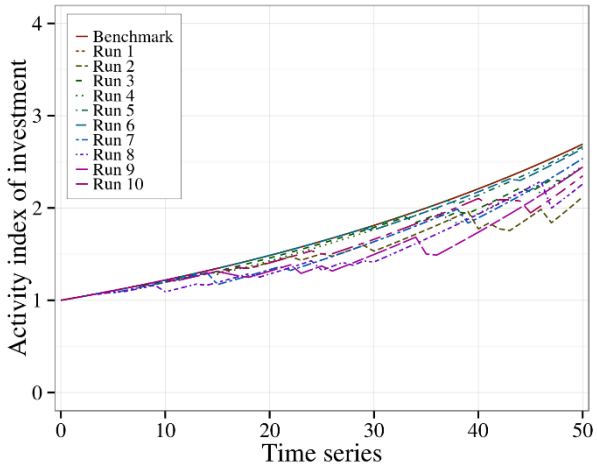
Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Model and assumptions

- Simulations with toy model
- Two polar assumptions about private agents' anticipation relative to flood risks
  - 'perfect foresight': actors know when and what flood will occur -> optimal adaptation
  - 'hazard blindness': no anticipation that floods may occur and no learning from events -> no proactive adaptation
- No public adaptation yet

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Perfect foresight vs. hazard blindness (10 runs)

	Perfect foresight	Hazard blindness
Capital stock		
Investment		

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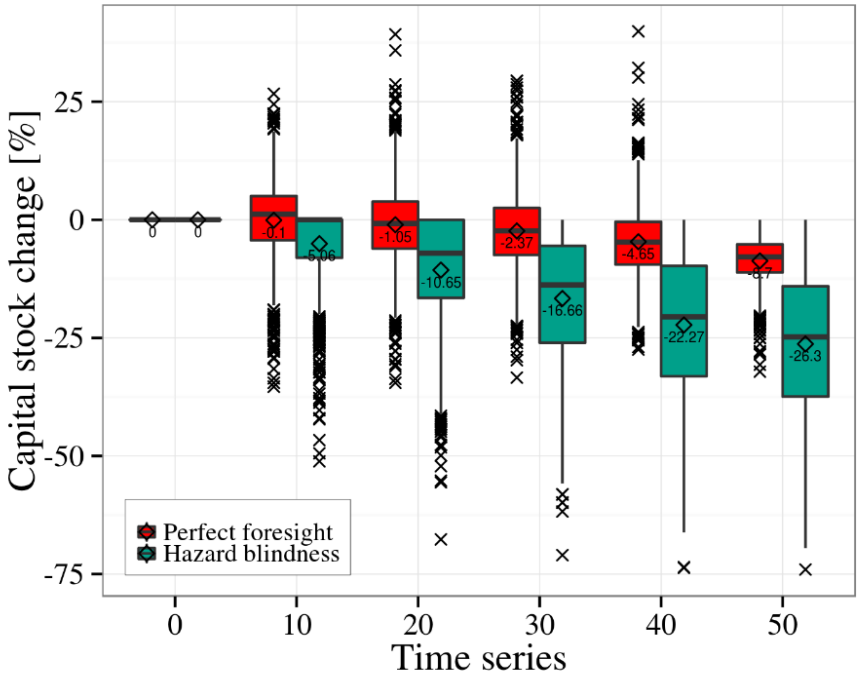
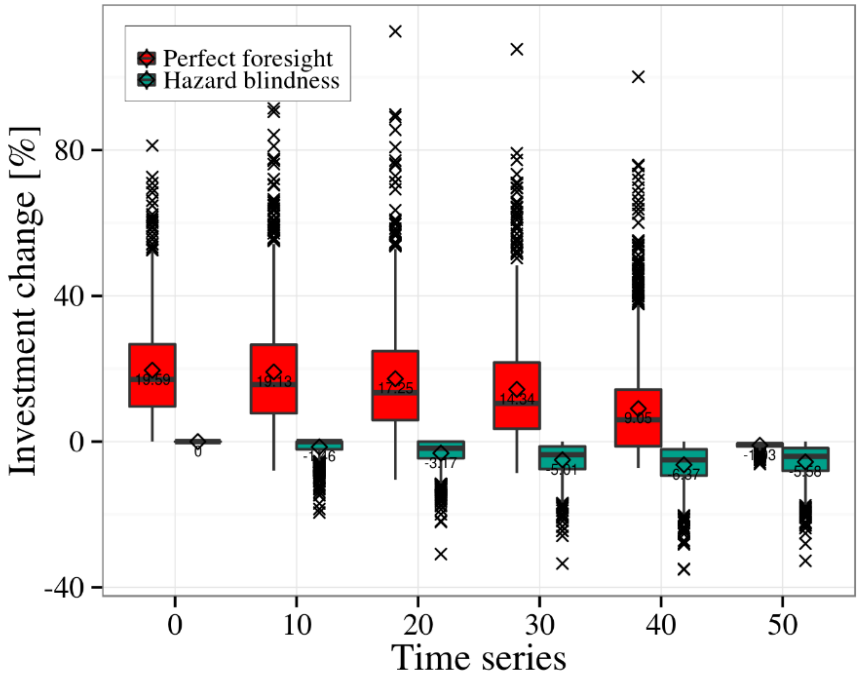
ENAC IA LEURE
philippe.thalmann@epfl.ch

Monte Carlo simulation (1000 runs)



(a) Capital stock



(b) Investment

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Core of the research

- How to improve on sub-optimal decision-making for adaptation
- Focus: decision-making under flood hazard uncertainty
  - risks may be neglected before they materialize
  - surprising extreme events are likely to induce additional adaptation
  - agents may under- or overestimate damage increase through climate change
    - what is our own knowledge base in this respect?
    - how does a society learn?
    - how do scientists learn?
    - learning as part of the adaptation strategy?

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Goals and means

- Quantitative assessment of flood damages with different adaptation options
- CGE model with a multi-region/multi-tier setting
- Main data and knowledge input:
  - Swiss input-output table (2008), data on sectoral output and employment at municipality level, and data on commuting (Swiss Statistics)
  - data on representative flood damages by municipality (WSL)
  - aqua-protect data on regional vulnerability ('impact' group)
  - financing strategies ('theory' group)
  - interaction between national and regional government ('policy' group)

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ENAC IA LEURE
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Key modelling choices

- Dynamic Ramsey-type model with a time horizon of 2100 and 5-year periods
- Regional disaggregation by distinguishing land that is
  - more or less vulnerable to floods
  - an input factor for production or assimilated to households consumption
- Sectoral disaggregation: Sectors I, II and III have different production structures, especially with respect to land use
- Impacts of floods are described through damages to uncovered land and land covered with immobile capital and infrastructure

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Key modelling choices - adaptation

- Damage functions are calibrated to WSL data
- Adaptation reduces lands' vulnerability to floods
- Only public adaptation is analysed:
  - land-use planning
  - establishment of protected areas
  - flood protection constructions
- Differentiation between local and national adaptation measures, i.e. provided either by the regional or the national government
- Analysis of different forms of adaptation funding

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Expected results

- Advancements in CGE modelling of
  - flood risks
  - adaptation measures
  - decision-making for adaptation under uncertainty
  - decision-making for adaptation in a federal context
- Estimates of the cost of myopic policies under alternative flood scenarios and decision rules
- Finding realistic means to improve on the decision-making for flood adaptation
  - what are the most costly mistakes that we make?
  - what simple rules or spread of information could avoid these mistakes?

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

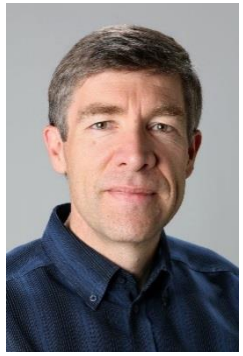
Teams

Christin Hoffmann
Uni Berne

Gunter Stephan
Uni Berne

Takafumi Usui
EPFL

Frank Vöhringer
Econability /EPFL

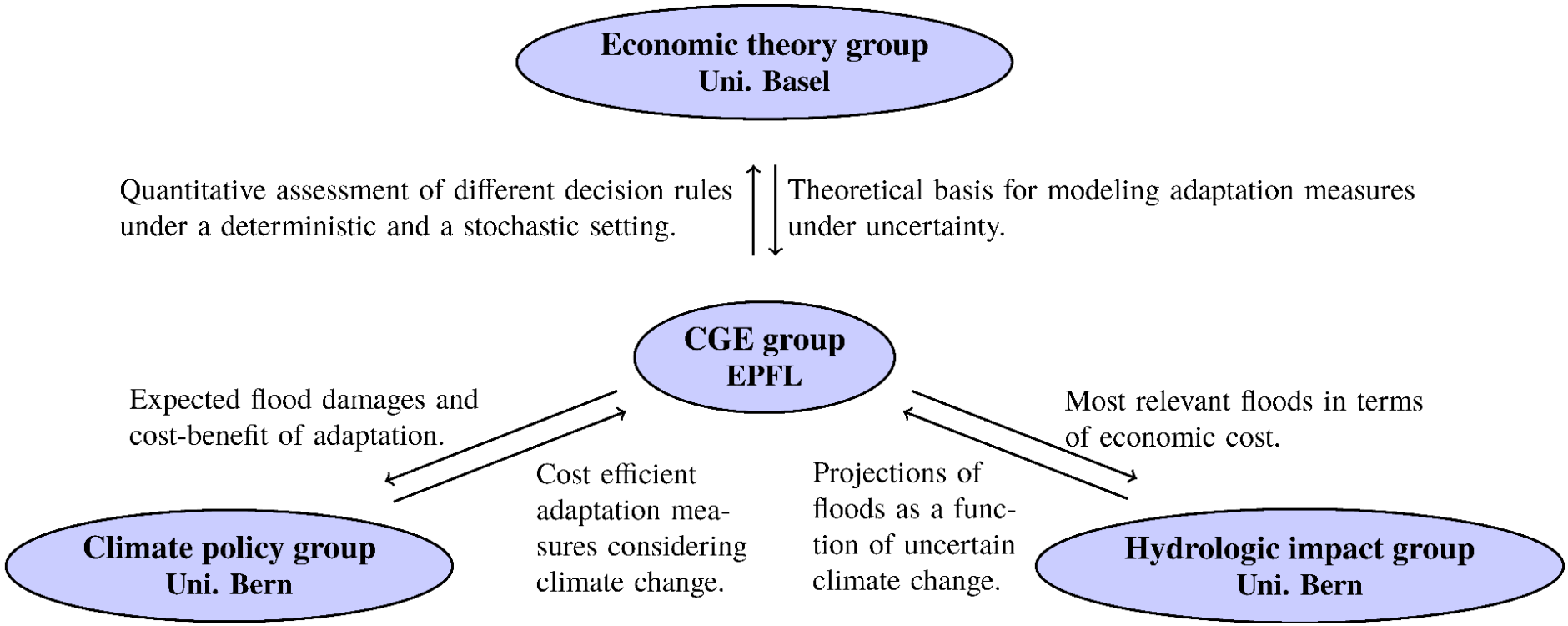


Philippe Thalmann
EPFL

THANK YOU FOR YOUR ATTENTION

Prof. Philippe Thalmann
ENAC IA LEURE
philippe.thalmann@epfl.ch

Interdisciplinary collaboration



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