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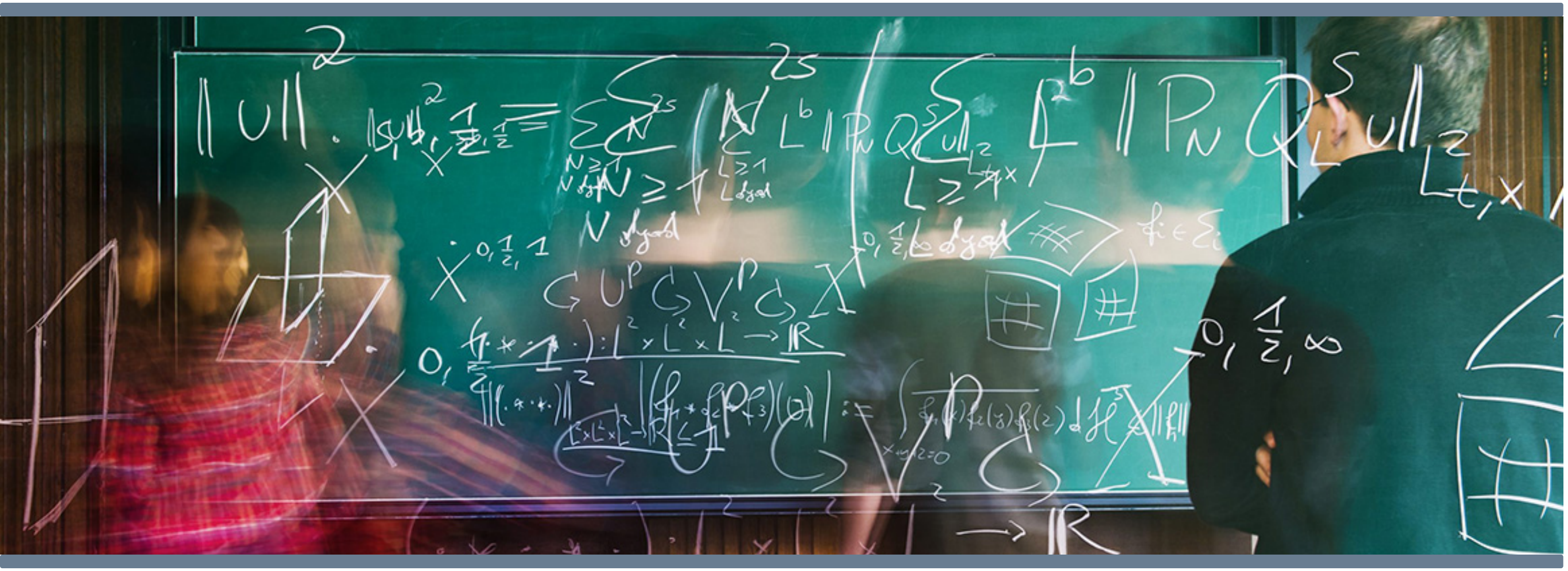


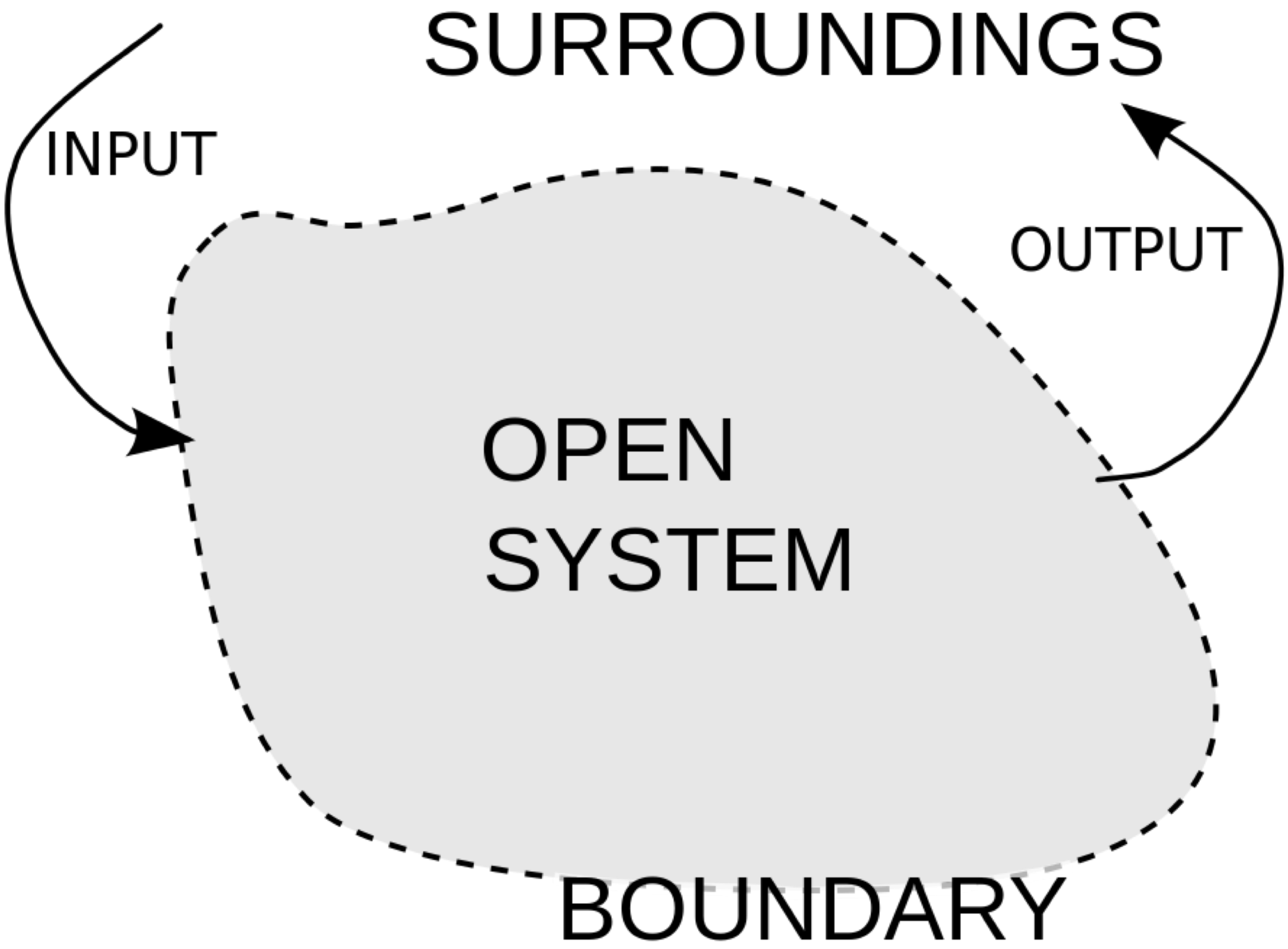
Simulation of a complex network using System Dynamics

Prof. Dr. Stefan N. Grösser, Bern University of Applied Science, School of Engineering

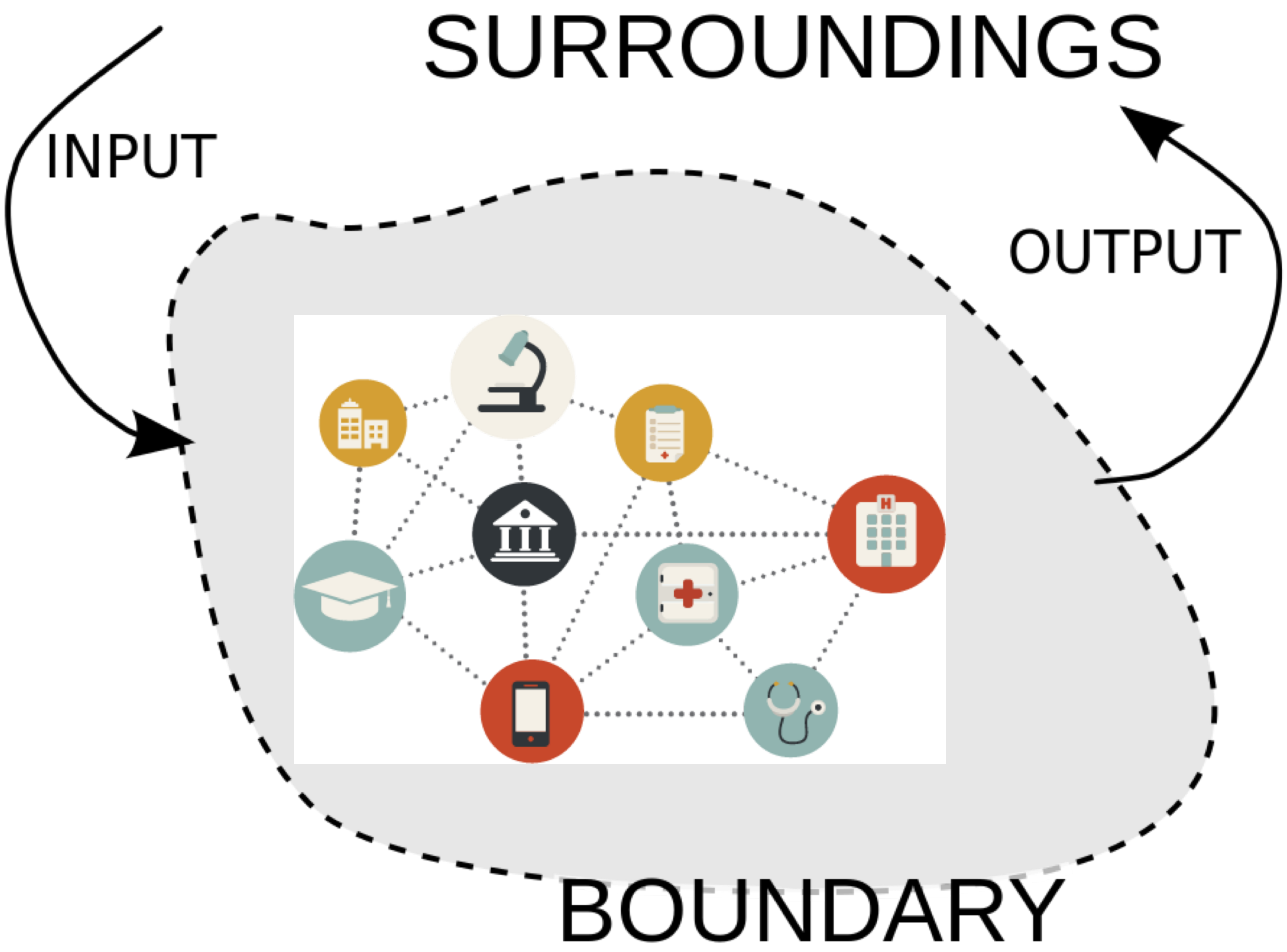
Disclosure of interest

- Nothing to declare

What is a complex system/network?



What is a complex system/network?



The history and present: Foresight as the crystal ball to understand complex networks

- Martin (1995): Research foresight is "the process involved in **systematically attempting** to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits"
- Georghiou (1996): Technology foresight is "a systematic means of assessing those scientific and technological developments which could have a strong impact on industrial competitiveness, wealth creation and quality of life"
- Miles (2000): Foresight is an approach that integrates three trends since mid-1990's
  - **Futures Studies**: Shift from predictive to exploratory approaches, iteration and involvement of users for embedding /implementation
  - **Strategic Planning**: shift from rational to evolutionary approaches, uncertainty is the norm, economic progress linked to disruptive innovations, qualitative vs quantitative changes within stable structures; long-term planning discredited but still needed.
  - **Policy Analysis**: Shift to open, participatory approach, knowledge is distributed and policy-makers have to find ways to capture it.

Classifications of foresight methods into categories

Dominant CF-Paradigm	Expert-based Foresight	Model-based Foresight	Trend-based Foresight	Context-based „Open" Foresight
Assumption	Knowability by Expertise	Calculability by Models	Projectability by Developments	Shapability by Interaction
Key Characteristics	Belief in Experts dominant, but: **70s: Turn to the qualitative and wider environment** First Opening towards "soft sciences" Scenarios	Quantitative and "subjective" models Extrapolation Systems **Dominated by "hard science"**	Trends Weak Signals Early Warning **Mix of qualitative and quantitative** Indicators	Integrating "soft" and "hard" approaches Understanding & interpreting / evaluating change Opening up: Participation, interaction & process **Action- and innovation-oriented** More attention on discontinuities
Perspective	Exploring Change	Calculating Change	Reacting to Change	Understanding & Anticipating / Shaping Change
Output	Delphis, Roadmaps, Scenarios	Models & Matrixes	Trend-databases Monitoring Systems	Scenarios; Wild Cards; Action Plans & Innovation Ideas

Assumptions of the different foresight categories

Assumption:
The future can be foreseen by collecting and comparing the opinions of (numerous) experts.

Expert-based Foresight

Assumption:
The future can be calculated by appropriate computer models based on huge amounts of data and mathematical finesse.

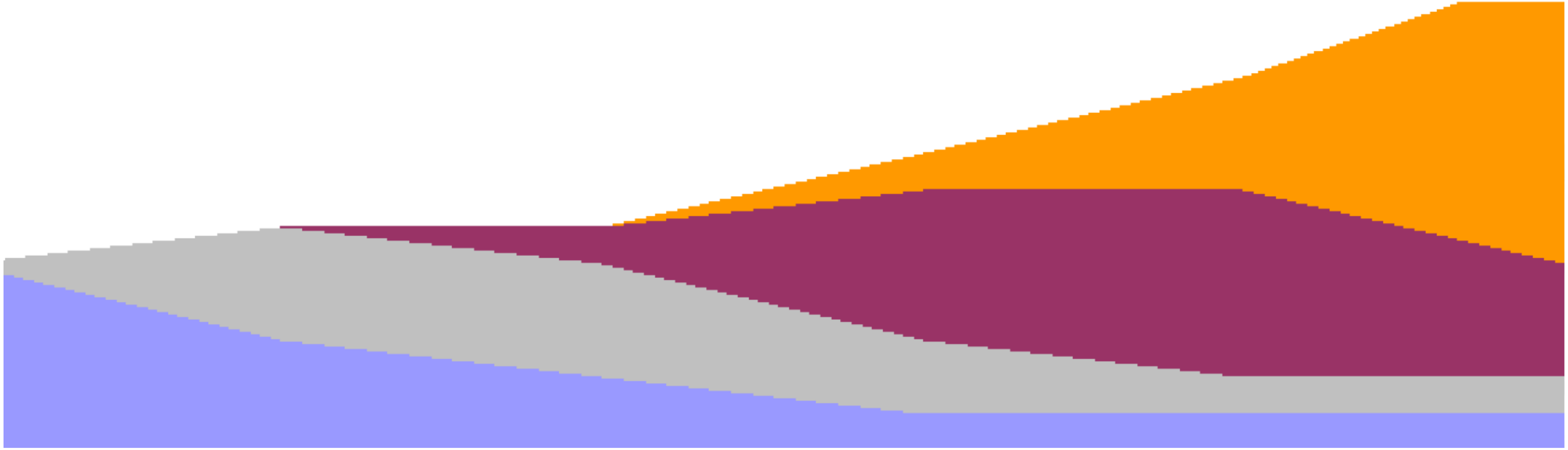
Model-based Foresight

Assumption:
Businesses can understand the future by anticipating the impact of trends on customers and markets.

Trend-based Foresight

Assumption:
Businesses can shape future contexts and markets by anticipating the dynamic interaction between social, techn. & economic forces.

Context-based („Open“) Foresight



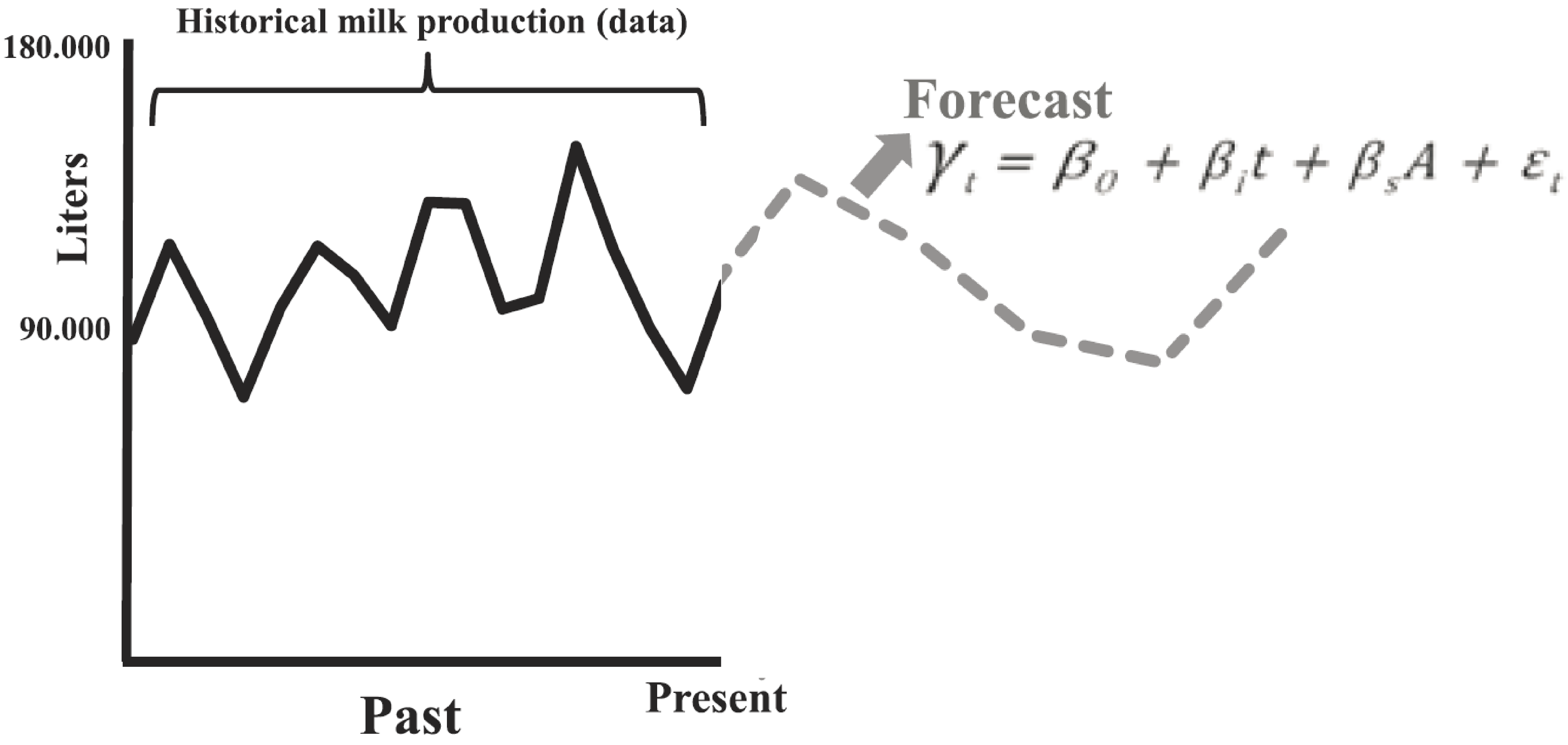
Managing Through The "Rear View Mirror"…a dangerous practice for any organization!

Case Example: Forecast the Milk Production …

When is a model or a decision support tool “good” or “useful”?

- **Construct validity**, i.e., has the “variable” we talk about the same meaning/semantics?
- **External validity**, i.e., representation of the modeled aspects of reality is valid
- **Internal validity**, i.e., structural validity of the elements
- **Usefulness,** i.e., Does your analysis offer interpretations that people can use in their everyday worlds? Are the insights from your model actionable/implementable?
- **Resonance**, i.e., stakeholders participate in the process, does your result make sense to your participants or people who share their circumstances?
- **Credibility**, i.e., is your research sufficiently grounded in data?
- **Predictive accuracy**, i.e., is the pattern prediction and/or point-estimation appropriate? (e.g., test-retest

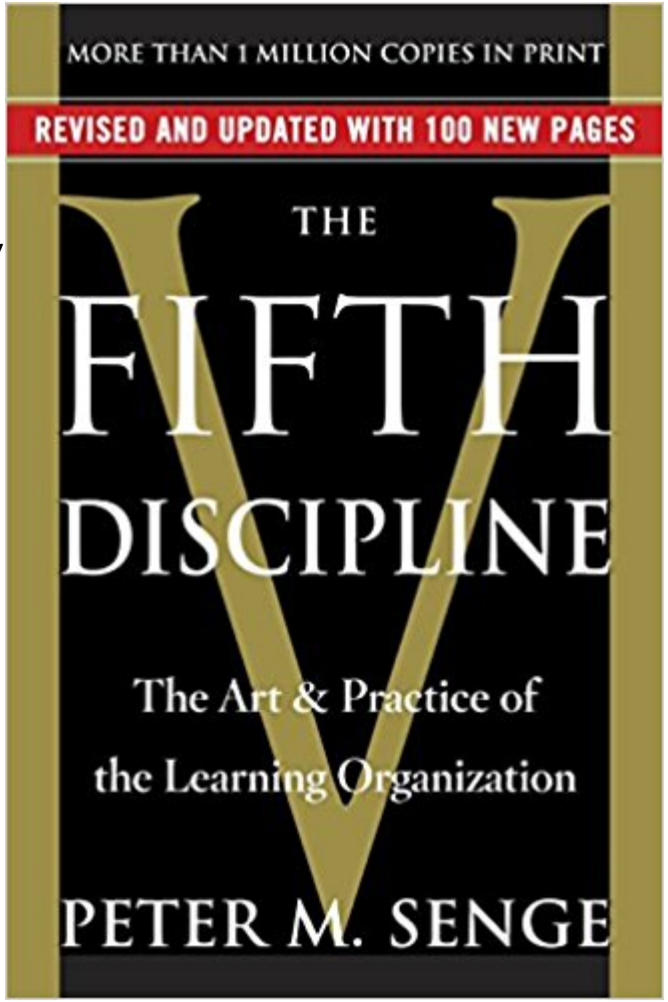
You are the decision maker in the production facility…



A reflection about complexity and complex networks

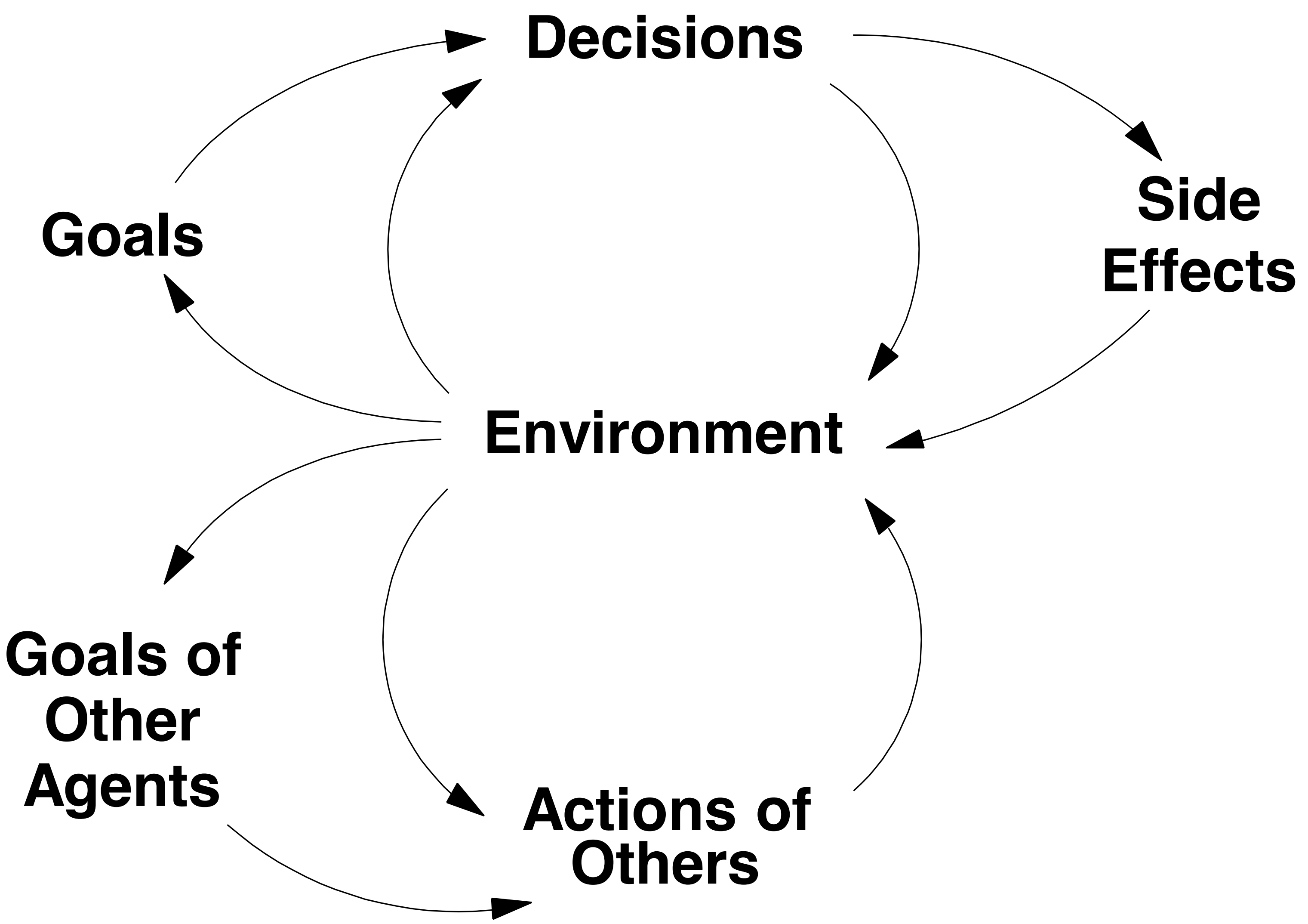
- "The reason that sophisticated tools of forecasting and business analysis, as well as elegant strategic plans, usually fail to produce dramatic breakthroughs in managing a business - they are all designed to handle the sort of complexity in which there are many variables: **detail complexity**." Peter Senge (The Fifth Discipline)

- "The second type is **dynamic complexity**, situations where cause and effect are subtle and where the effects over time of interventions are not obvious. **Conventional forecasting, planning and analysis methods are not equipped to deal with dynamic complexity**. The real leverage in most management situations lies in understanding dynamic complexity not detail complexity." Peter Senge (The Fifth Discipline)

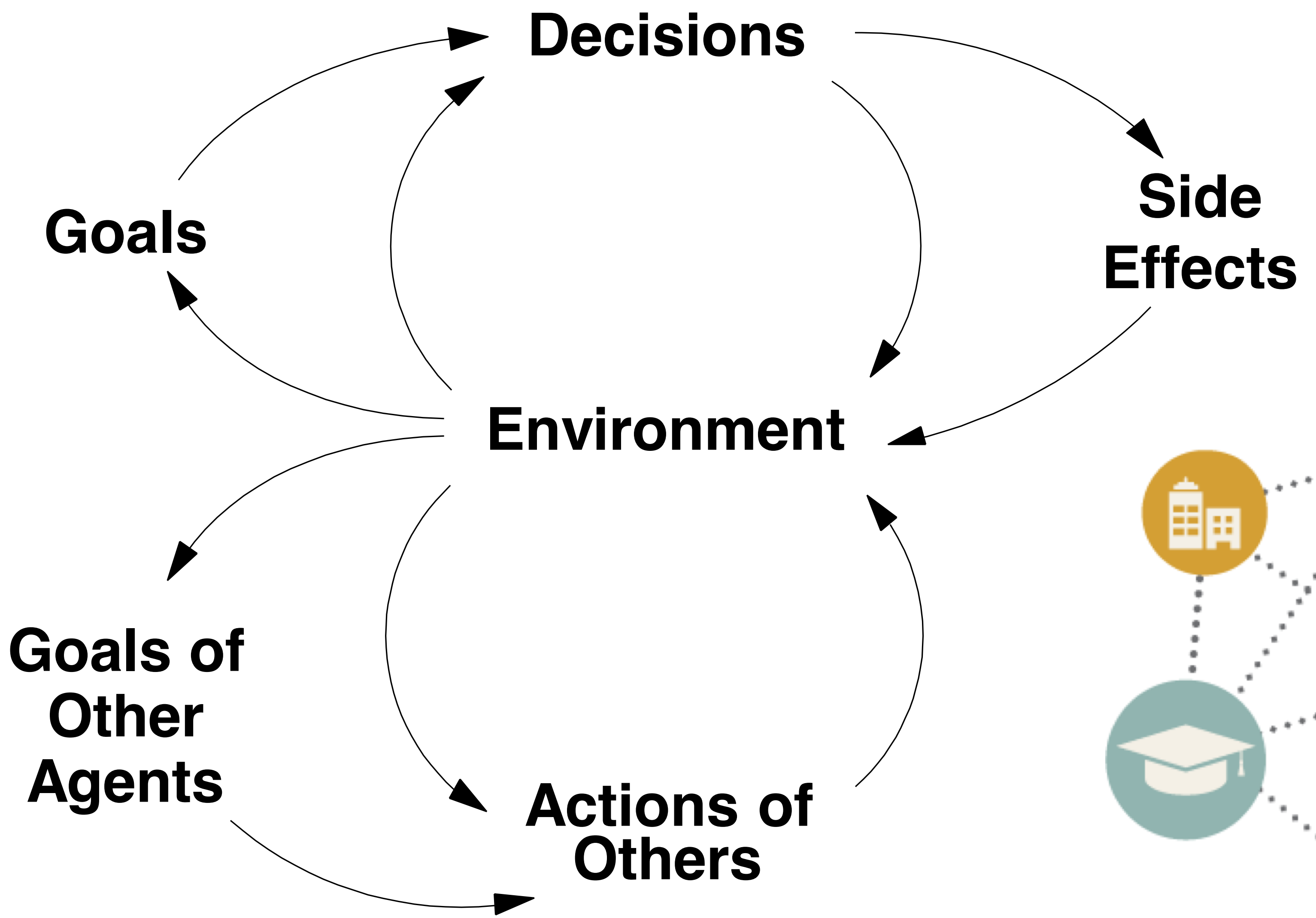


Complexity and Reactive Behaviors and Causal Simulation Modelling with System Dynamics

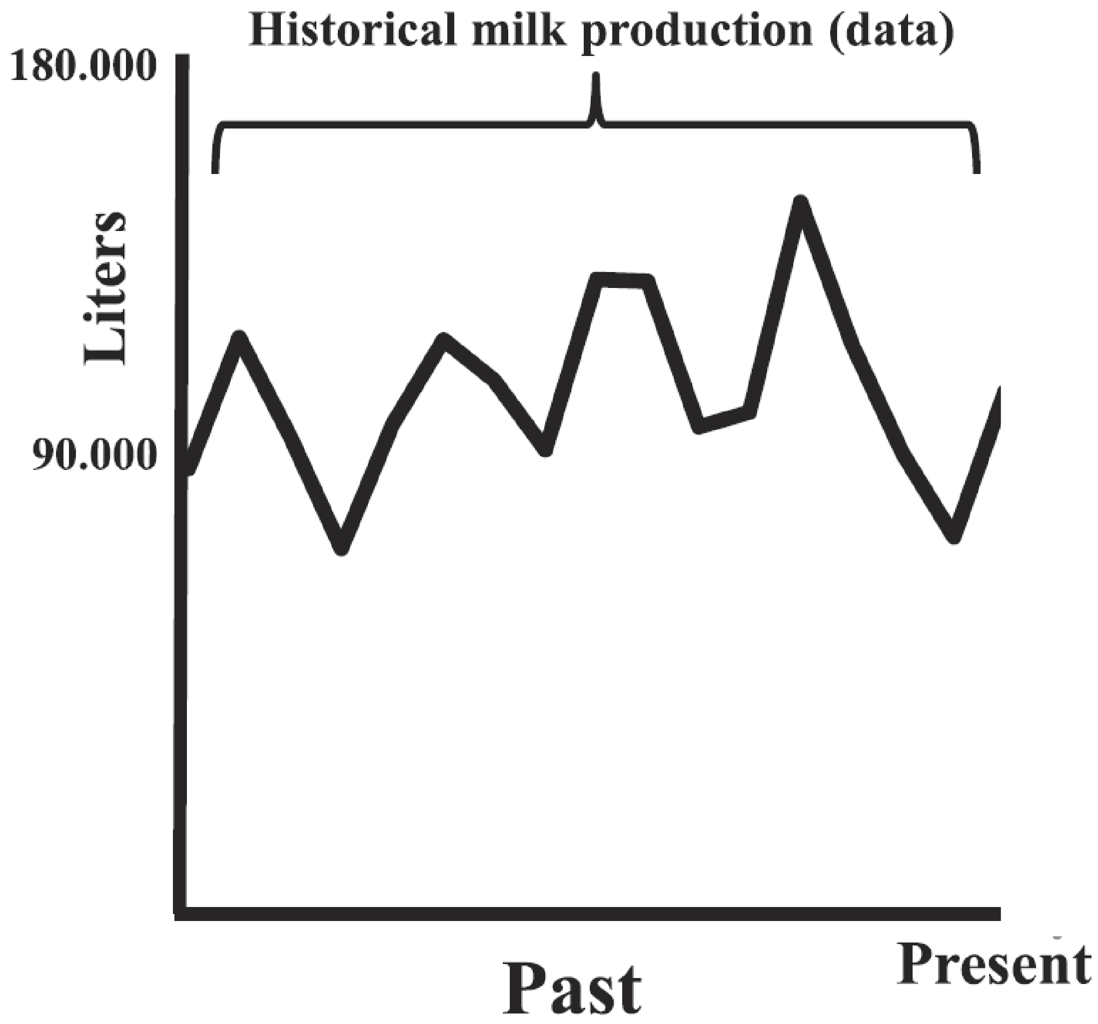
(Dynamic) Complexity



(Dynamic) Complexity

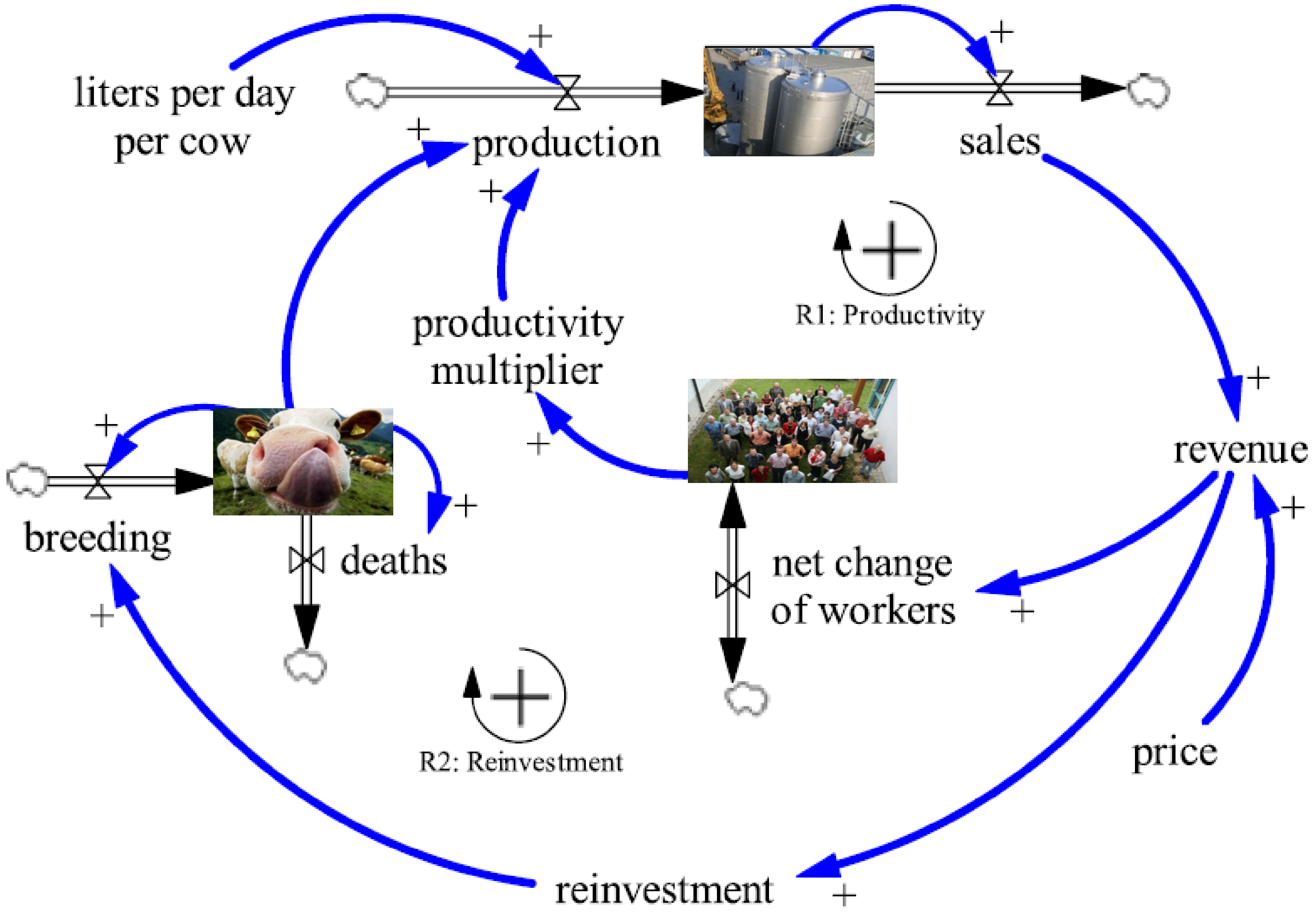


Objectives first…we need a model that works and explains "performance" over time



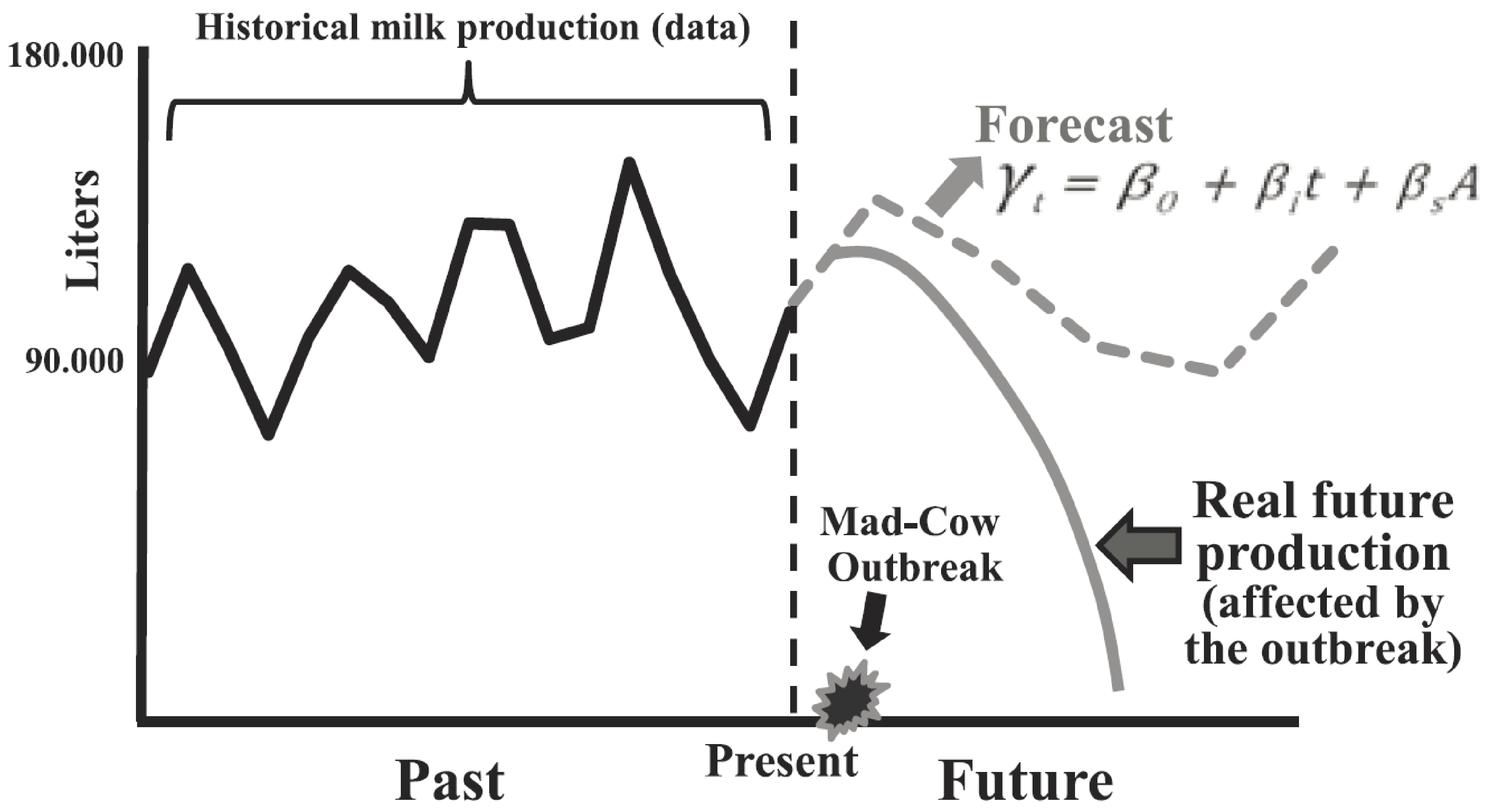
Then second, we need to account for the physical system…

A structural, causal model for the explanation of milk production

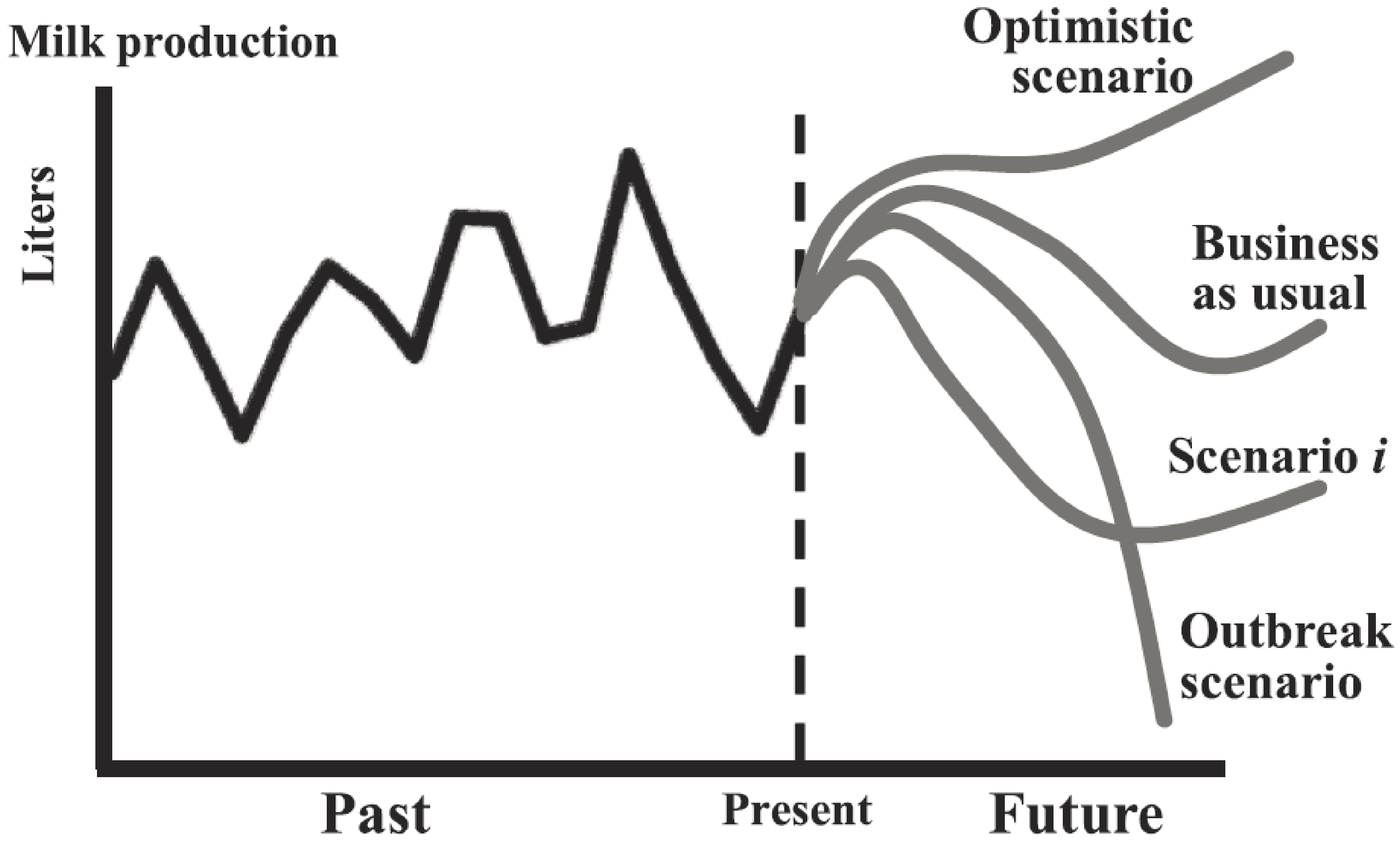


Only after the (most likely) causal structure is uncovered and the past behavior is explained, then there can be scenario analysis and pattern estimation

Objectives first…we need a model that works and explains "performance" over time

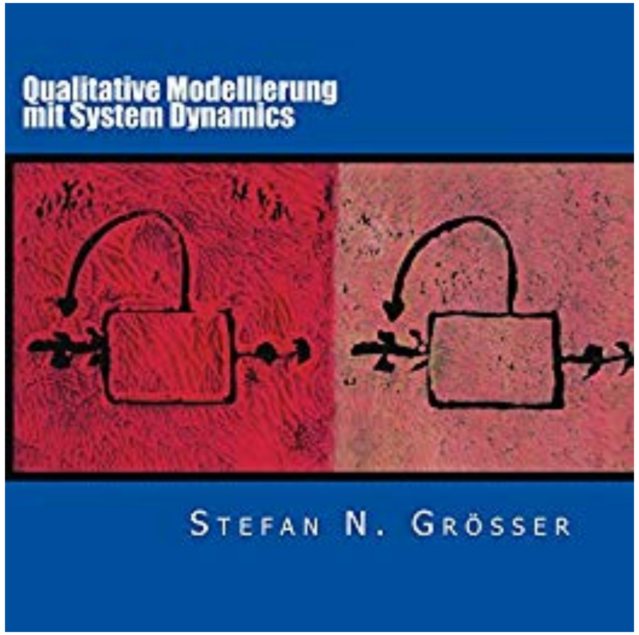


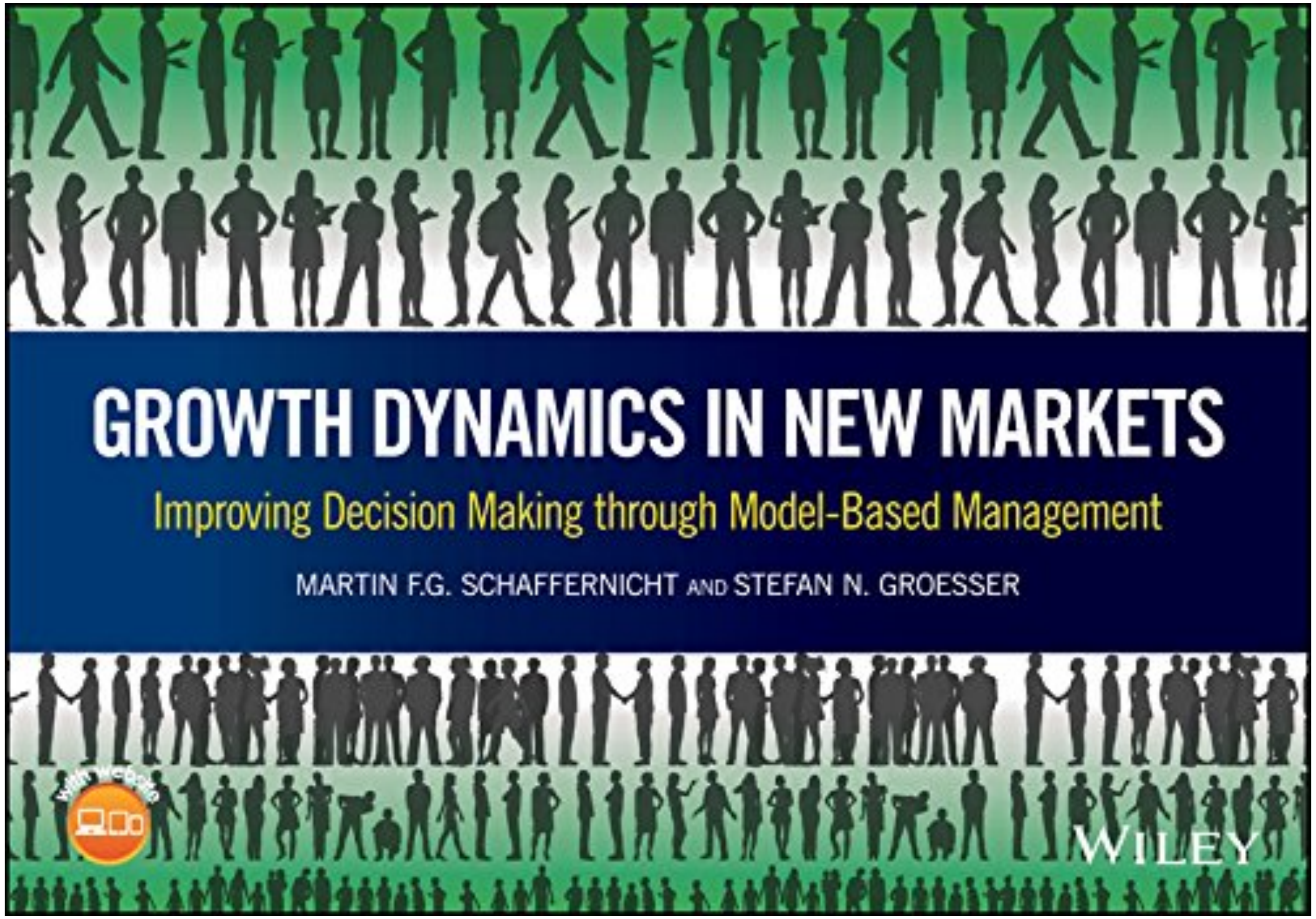
Validation: Models should be capable to replicate the historical data but should also be rich in realistic scenarios



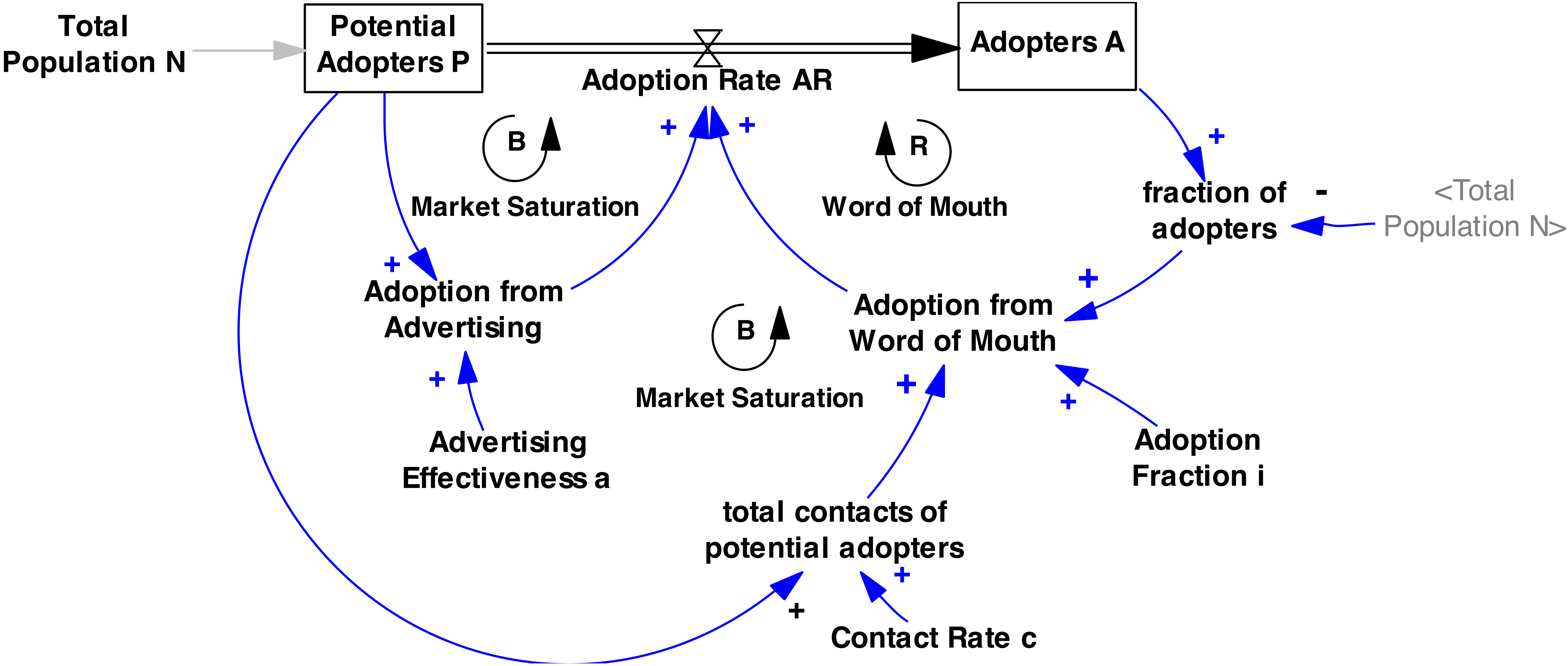
The approach is called System Dynamics

- Schaffernicht/Groesser, 2018, Wiley
- Develop your simulation model yourself step-by-step.
- Improved decision making.
- Self-study is the major part.
- Online Tutorial and challenges





101: A standard diffusion model to make a structural point



Result of a research project

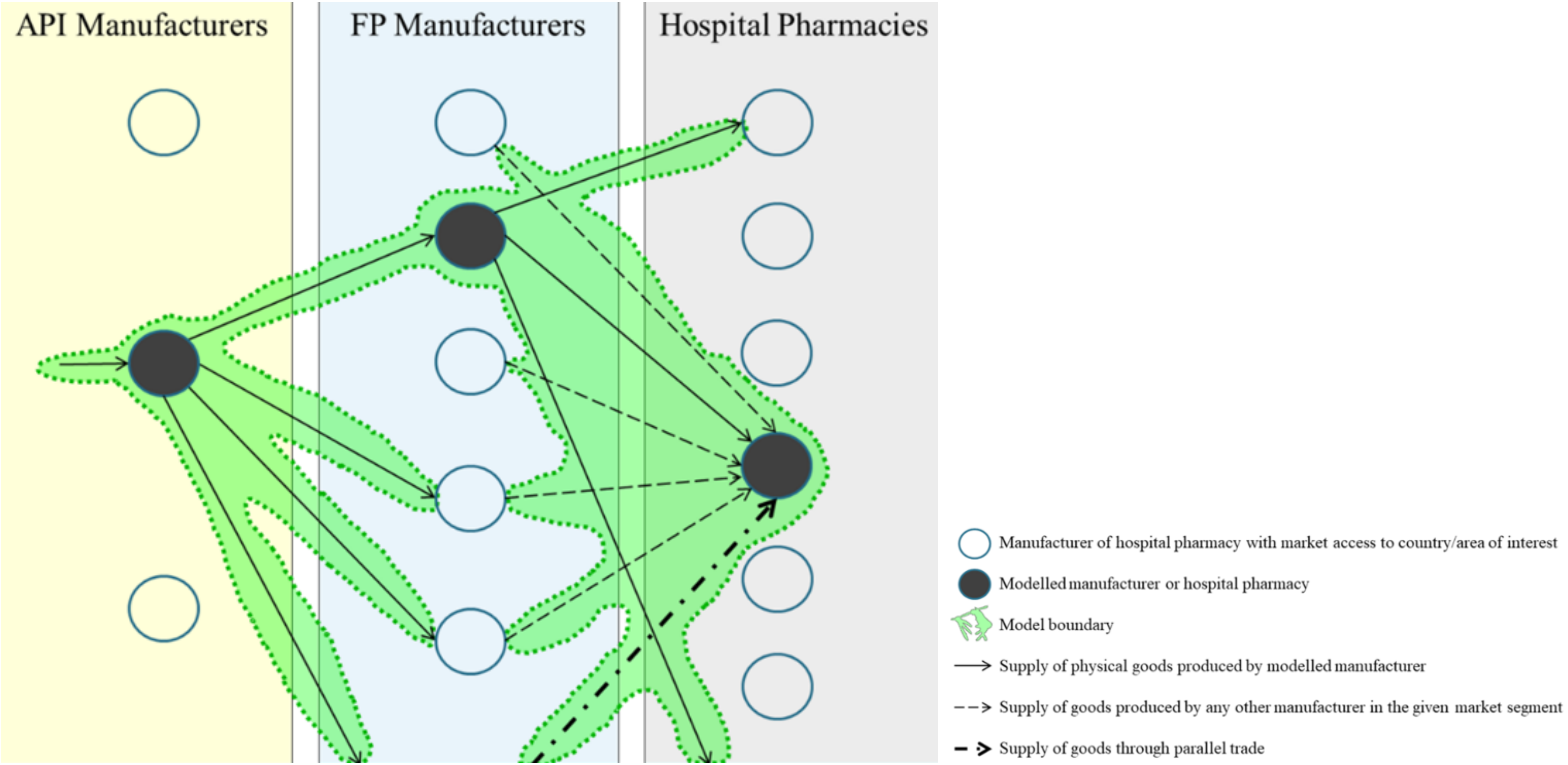
Chapter 9
Resilience as Basis for Sustainability: Shortages in Production Supply Chains for Essential Consumer Goods

Stefan N. Grosser and Lize Duminy

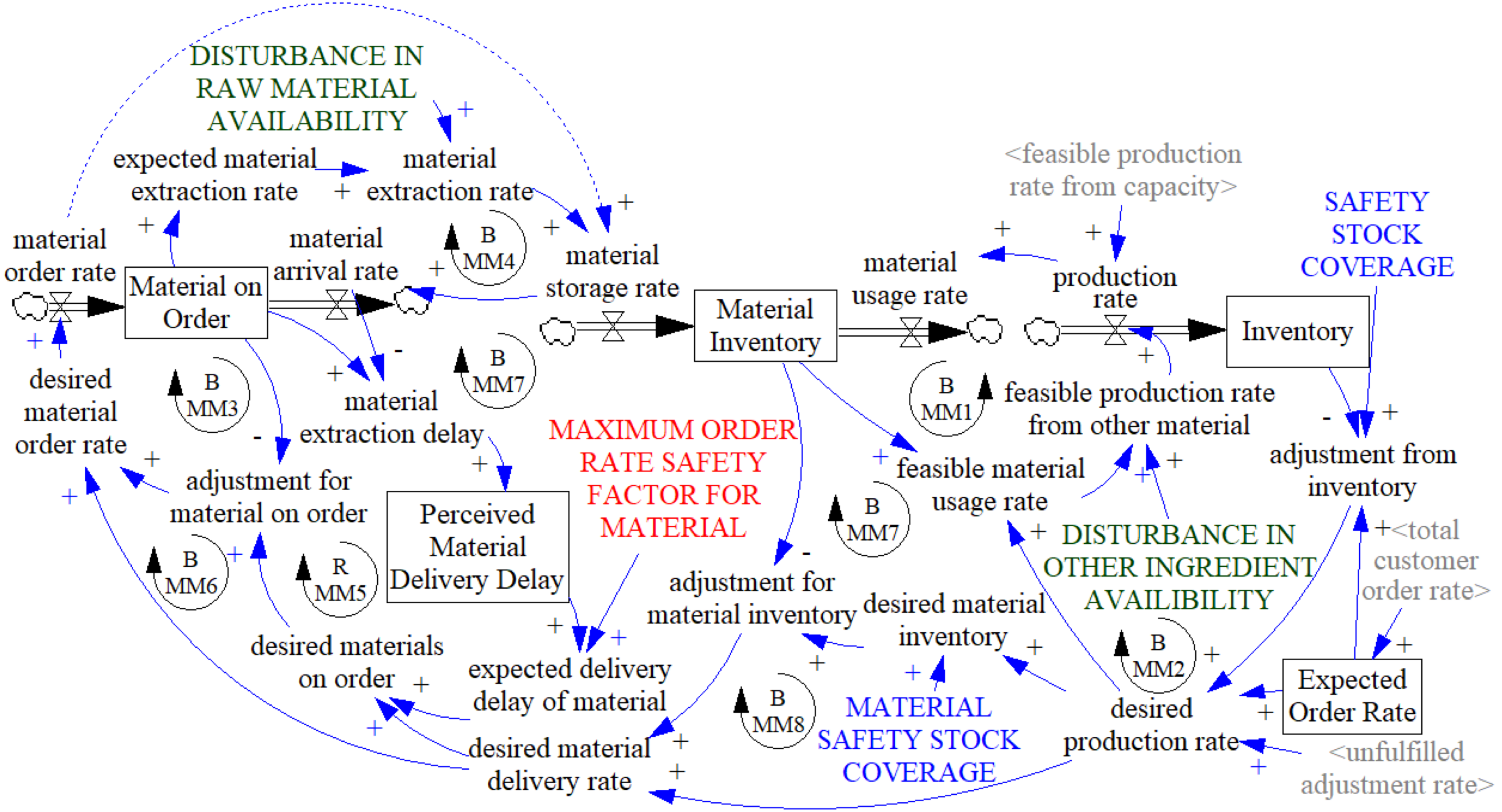
9.1 Introduction

https://www.springerprofessional.de/resilience-as-basis-for-sustainability-shortages-in-production-s/16079080

Assumptions in our model



One part of a model about the complex supply chain: purpose is to understand and “experiment” with medicine shortages



https://www.springerprofessional.de/resilience-as-basis-for-sustainability-shortages-in-production-s/16079080

What is up next? Hands-on workshop on “Experimentation with Simulation models” (14.45 - 16.15)

- You need your laptop.
- Connect your laptop with the Wifi network (password should be available)
- The tasks that we will do are available at specific URLs which I will display later in the workshop.
  - Understand the modelling approach
  - Explore the models
  - Criticize assumptions used in the model
  - Provide your feedback about the simulation
- If you are interested in the workshop slides be sure to include your email in the first online survey.
- I will use “time slots” to organize our hands-on workshop
- Questions: Stefan.groesser@bfh.ch

Sources used for this presentation

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