

Agent-based Modelling of Systemic Risk: A Big-data Approach

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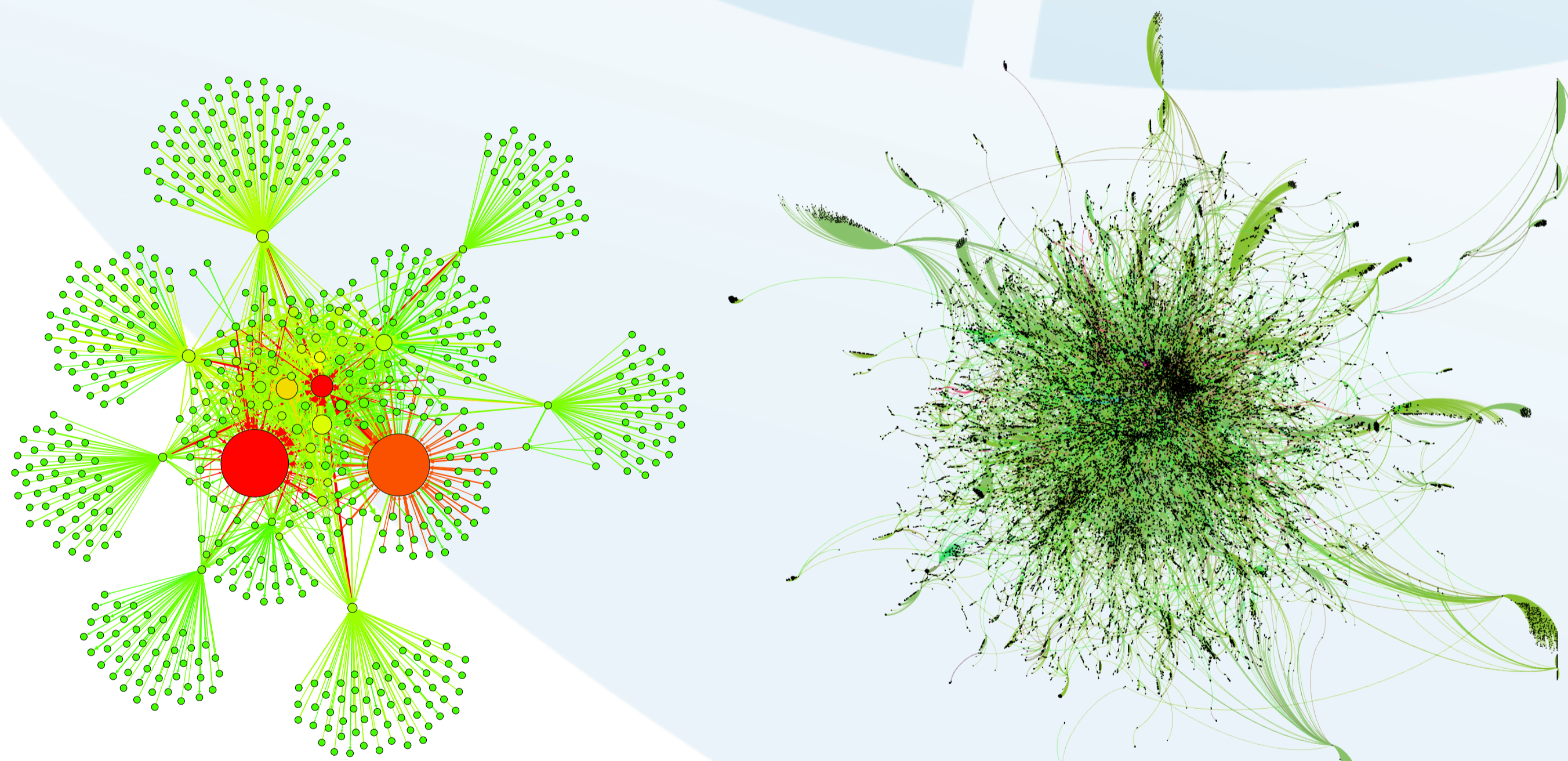
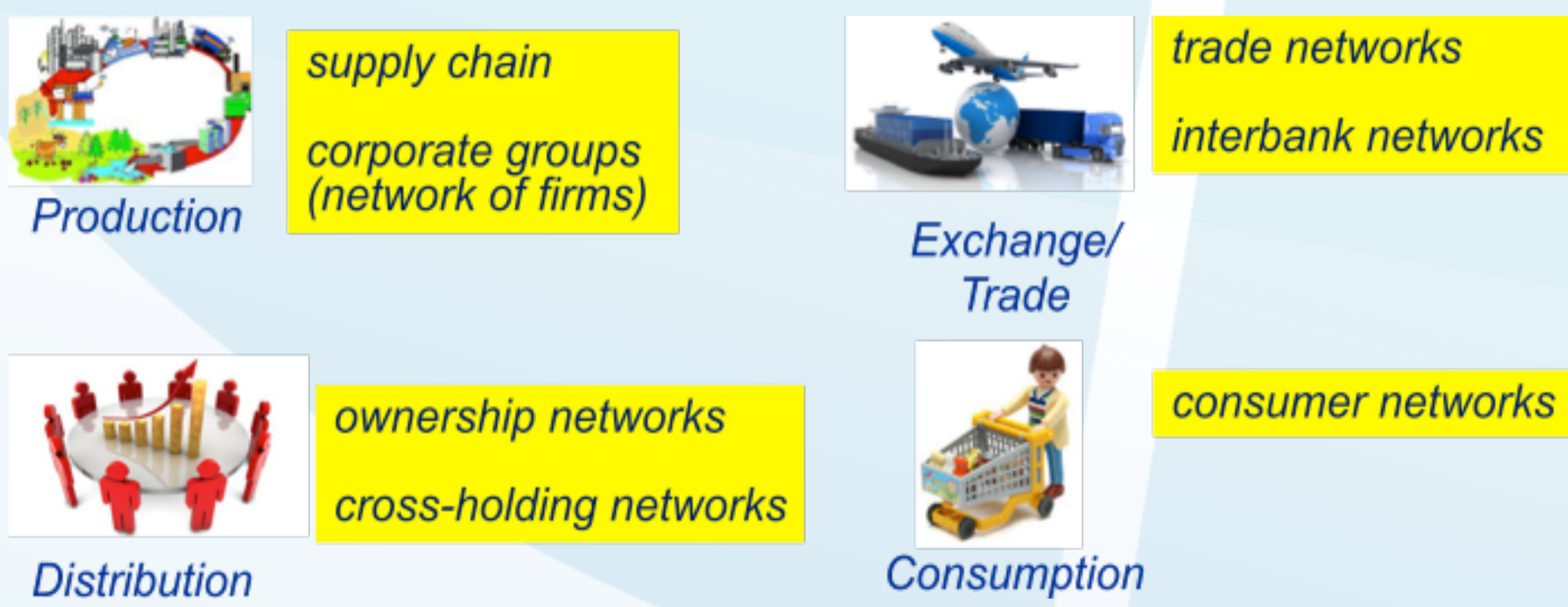
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Agent-based Models (ABMs)

- Model **individual agents** and their individual decisions - **decentralized decision making**
- **Emergent patterns** from micro-processes to macro level
- Account for **local interaction networks** between agents - **parallel computing** can be used
- Based on **micro-foundations** - **big-data** can be included
- **Very large models** that incorporate **low level details** possible - need for **supercomputing**

Local Interactions and Networks

- An economy is a network of **interacting firms, households, banks, etc.**
- **Out-of-equilibrium dynamics** of economic networks can be explicitly modeled using ABMs



Banking network of Austria in 2008 – based on data provided by the Austrian Central Bank (OeNB)

Ownership network of 170.000 Austrian firms in 2013 – based on data from the company register of Austria

Big-data

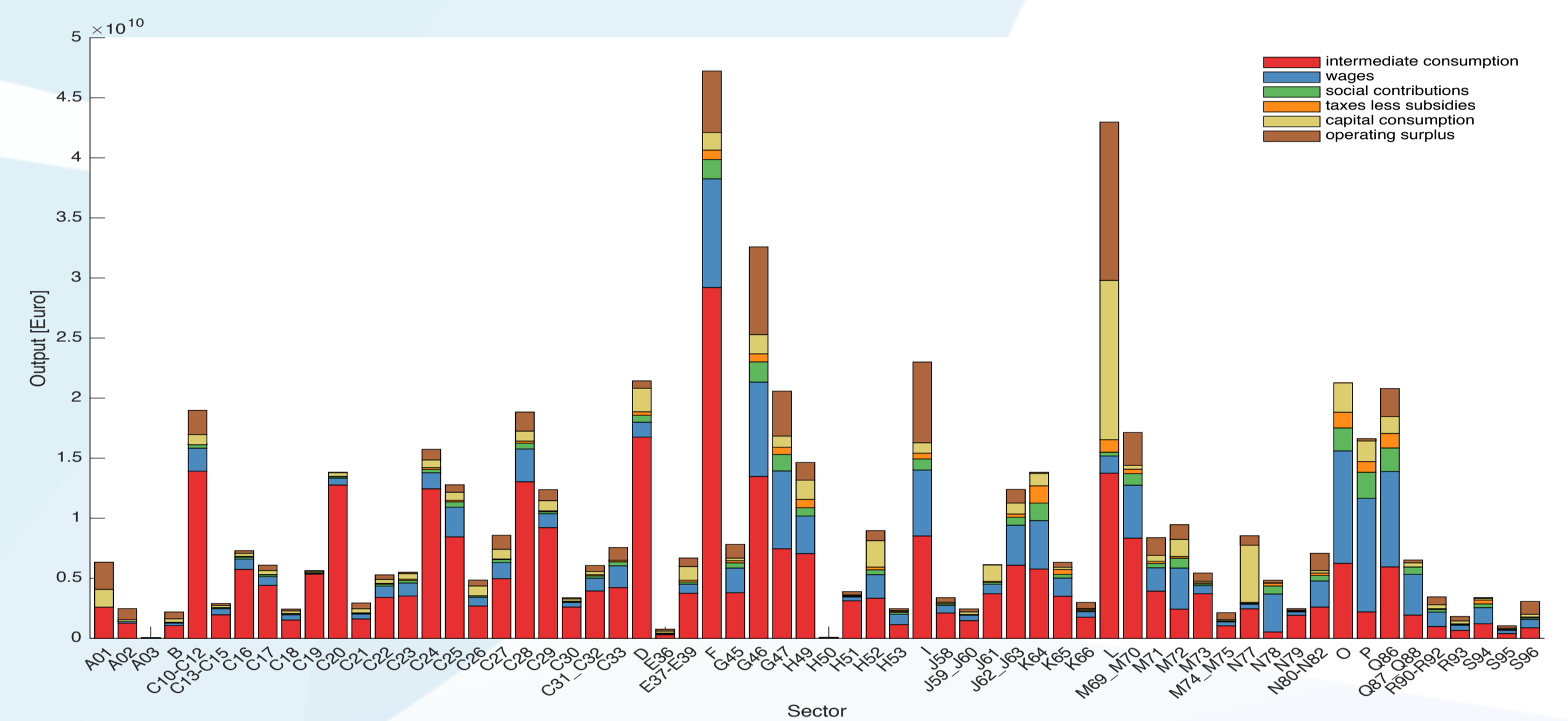
- The quality and quantity of economic data is expanding rapidly
- Shift from small-sample surveys to datasets with **universal** or **near-universal population coverage**
- Enables empirical calibration of agent-based models

Parallel Computing and Supercomputing

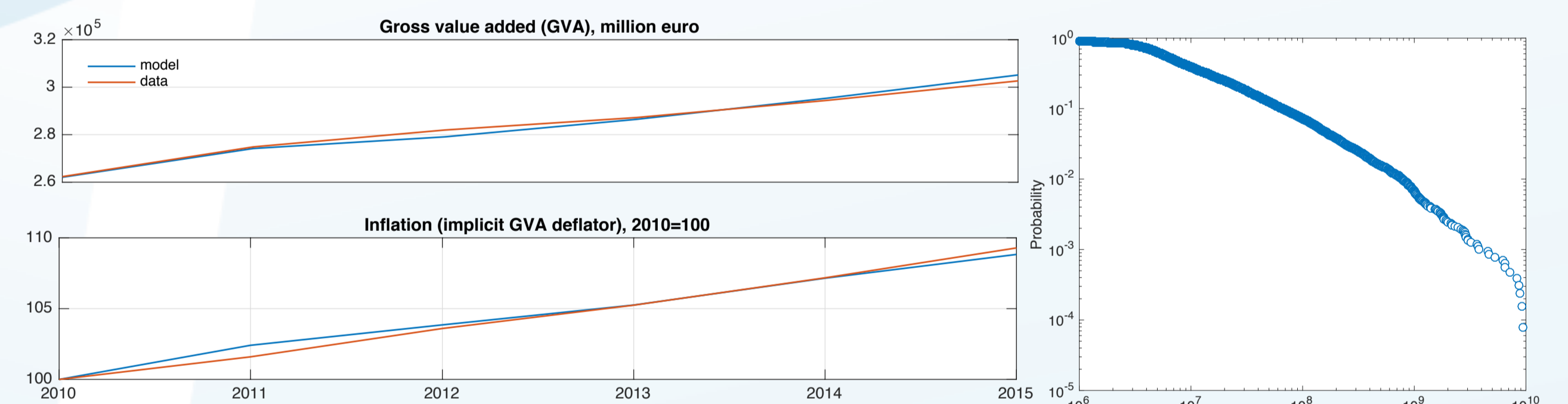
- Economic ABMs are intrinsically massively parallel computational systems
- Very large populations of agents perform complicated **local computations** (decentralized decision making)
- Agents have **precise positions** on physical and conceptual **networks** (local interactions)
- Natural and necessary to run large-scale ABMs on supercomputers

IIASA's ABM of a national economy

- Models the **complete national economy of Austria** with all institutional sectors (households, non-financial corporations, financial corporations, and a general government)
- Includes **all economic activities** (producing and distributive transactions) as classified by the European system of accounts (ESA)
- Includes **all economic entities**: all juridical and natural persons are represented by agents (at a scale of 1:10)
- Empirically **calibrated to actual macro and micro data** (national accounting, census and firm-level data)
- Simultaneously fits observed macroeconomic variables, stylized facts, and (some) observed distributions between agents on the micro-level



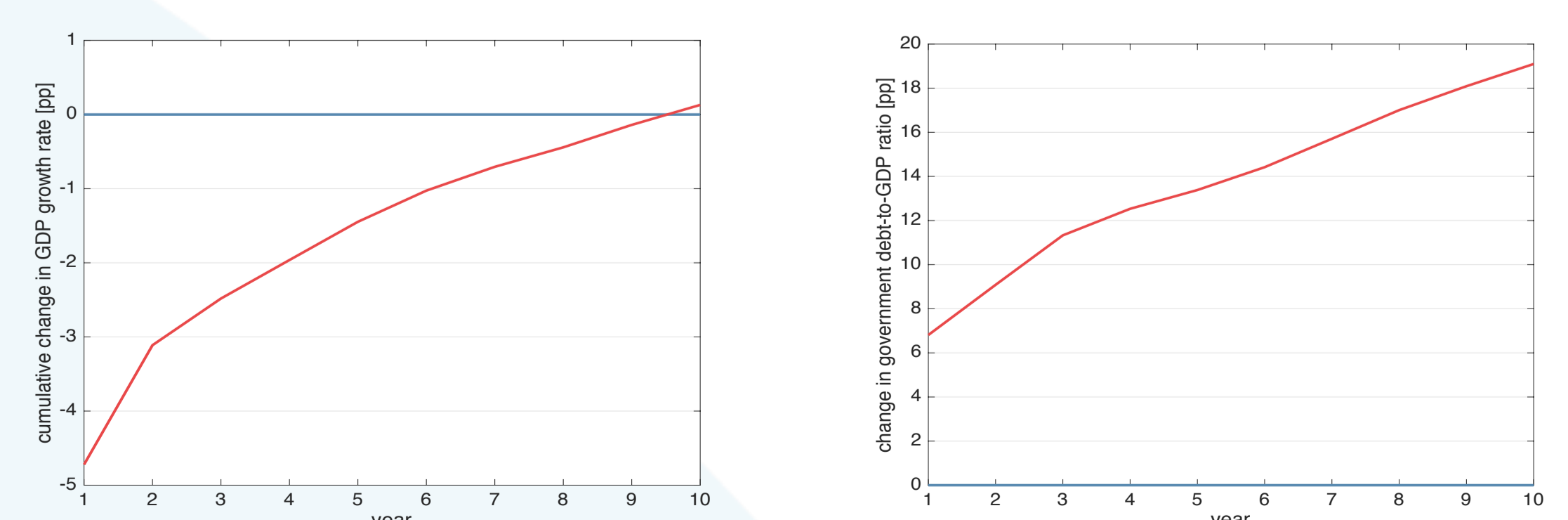
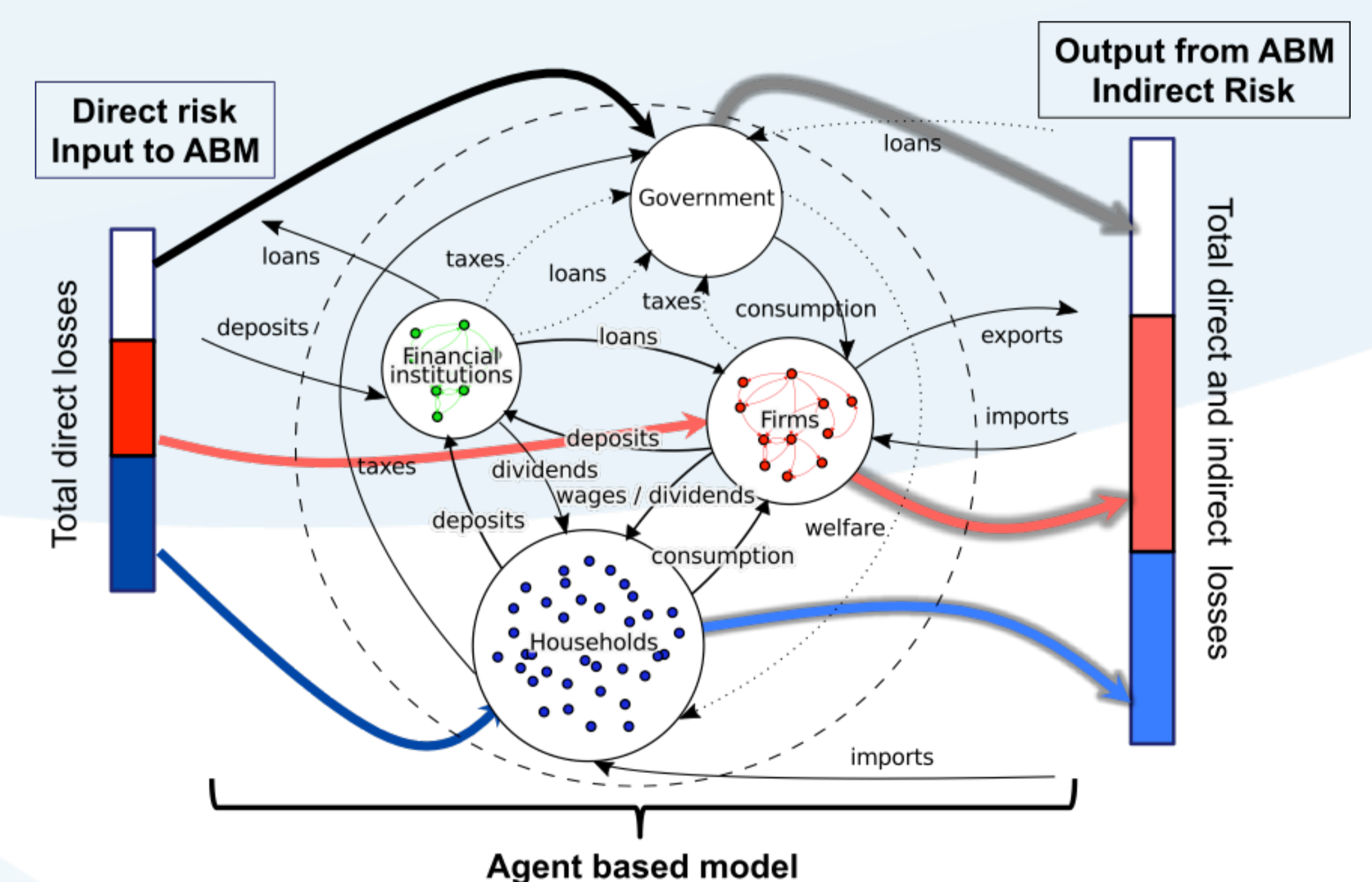
Distribution of output and cost structure by sector used as initial values for model simulations from observed data of Austria



Comparison of output (gross value added) and inflation for model simulations and observed data of Austria

Firm size distribution by output for model simulations

Application: Systemic Risk Triggered by Natural Disasters



Macroeconomic effect on GDP and debt of flooding affecting only productive capital of a 1500 year event in Austria – based on the ABM simulations