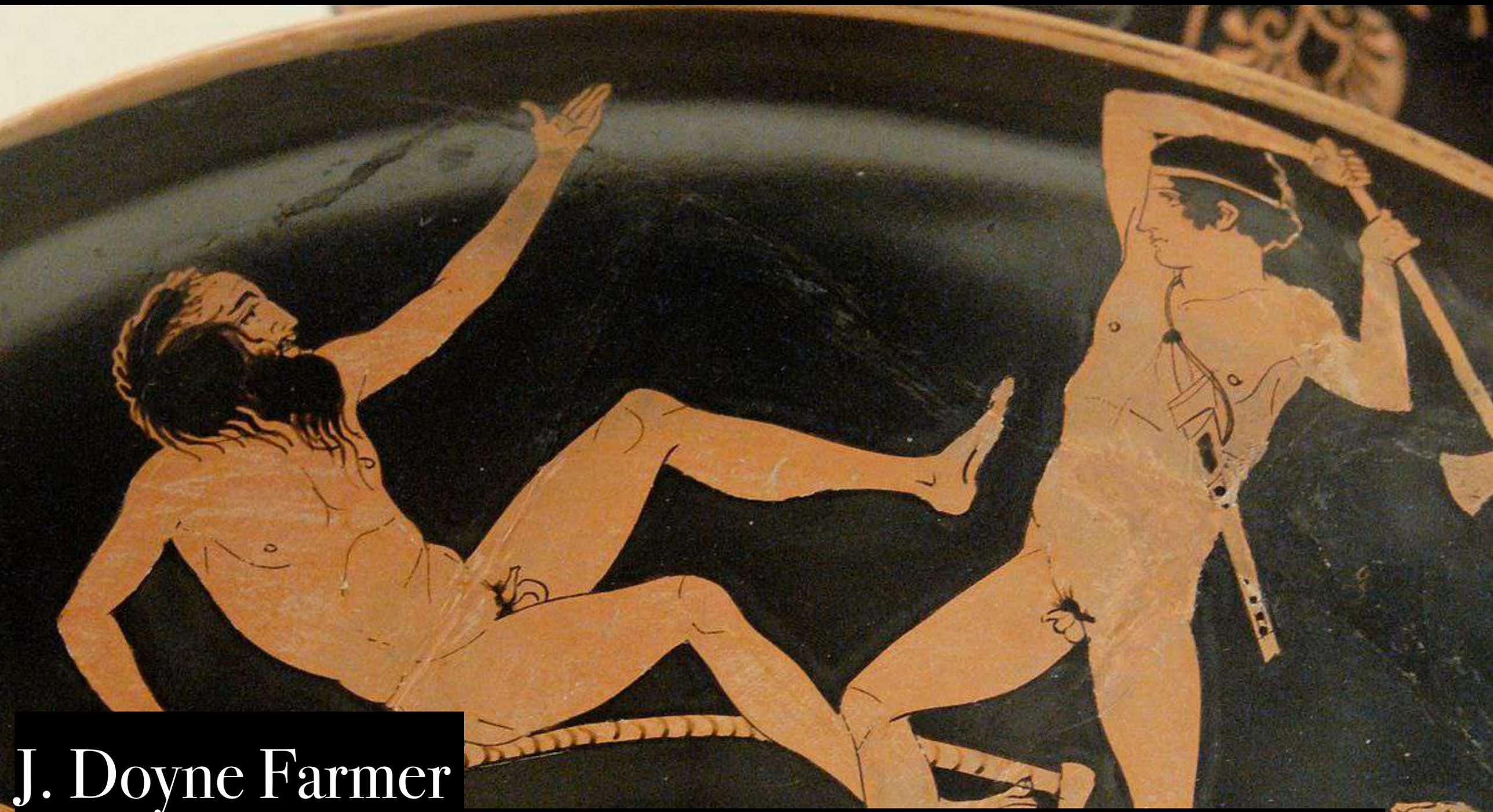
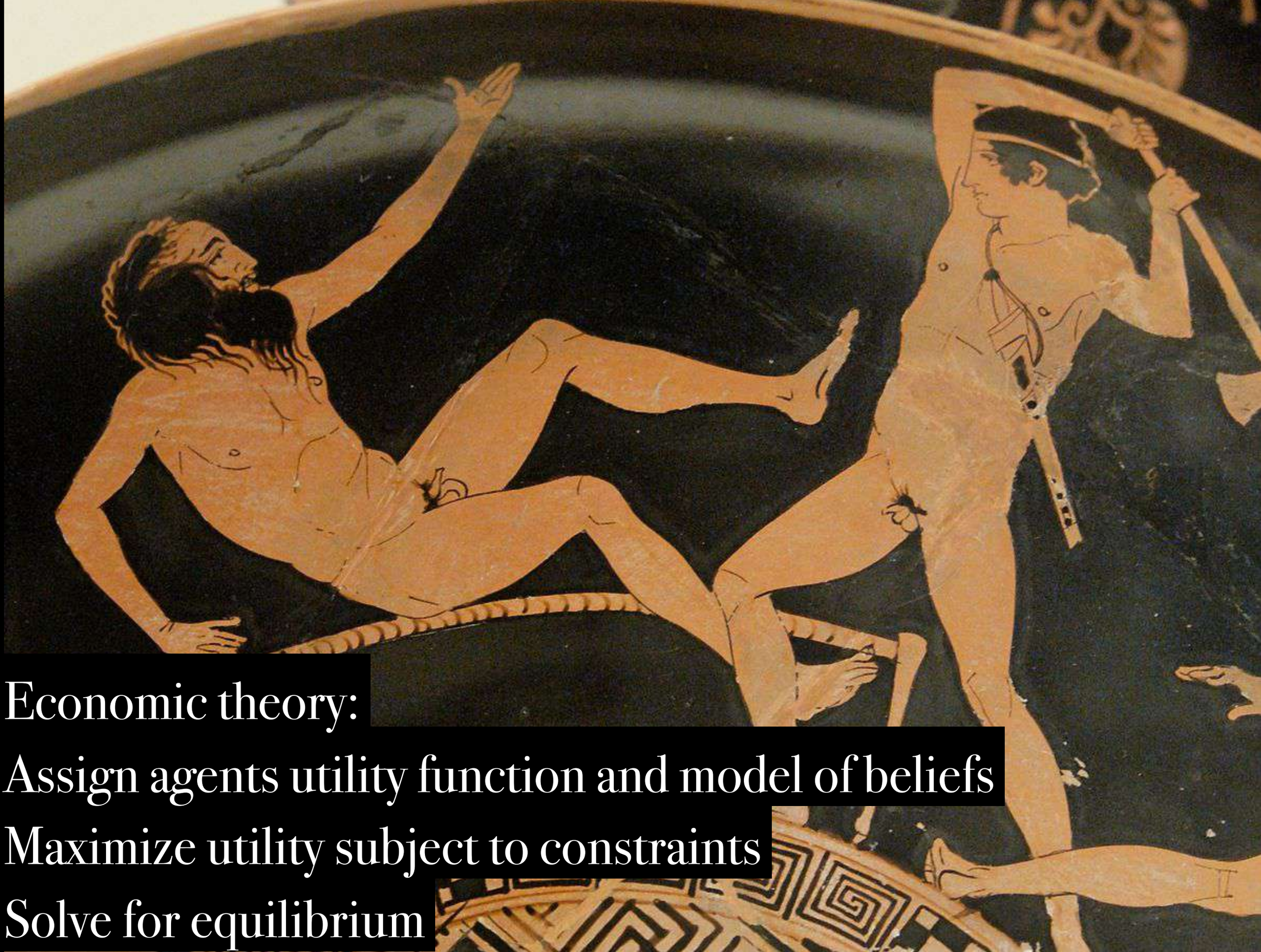
The complexity economics revolution



J. Doyne Farmer

Institute for New Economic Thinking at the Oxford Martin School, Math Institute, University of Oxford; Santa Fe Institute



Economic theory:

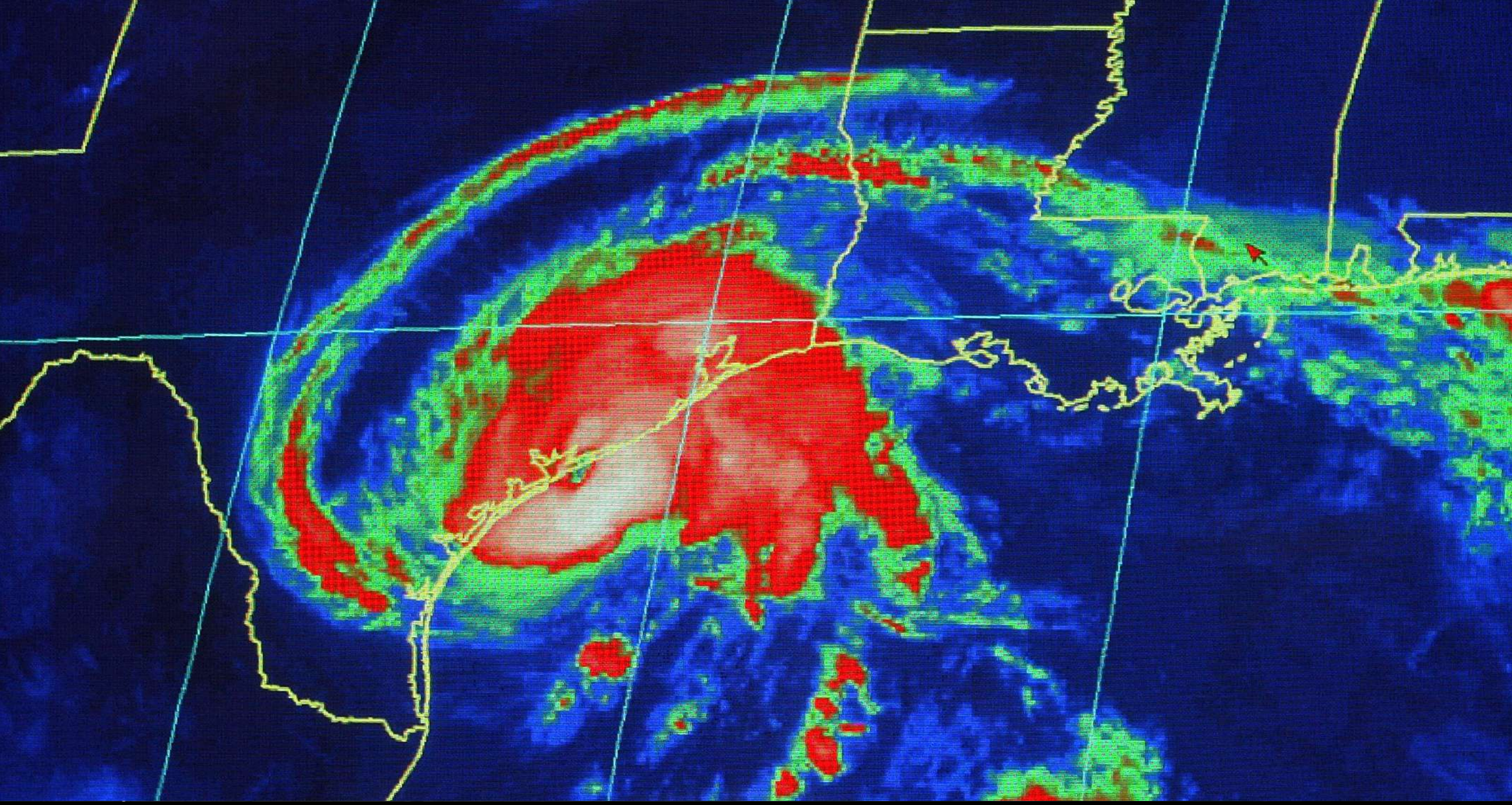
Assign agents utility function and model of beliefs

Maximize utility subject to constraints

Solve for equilibrium

Was austerity good for Greece?

Or was austerity like the sacrifice of Ifigenia?

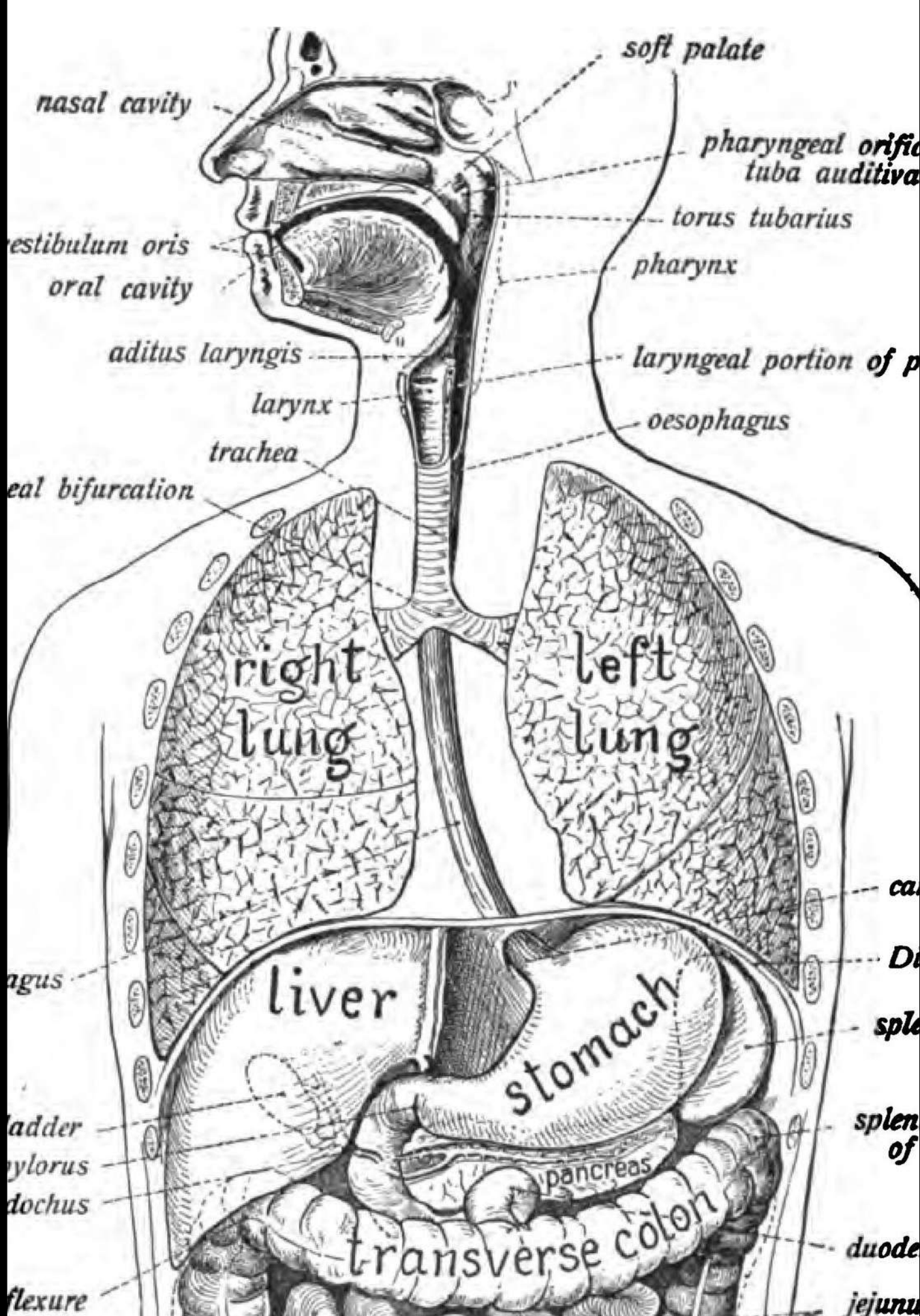


Science makes things that are random become predictable

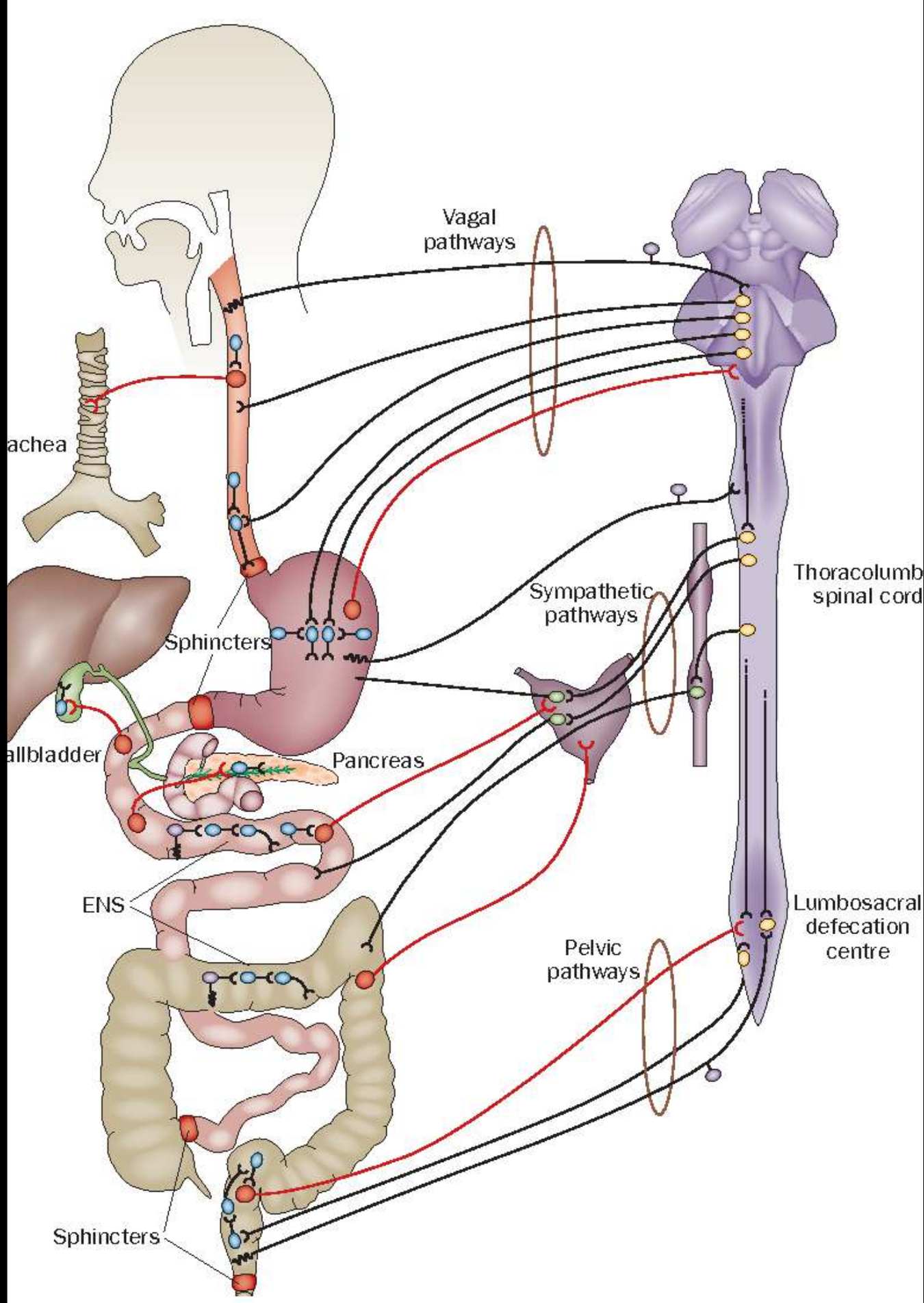
Complexity Economics offers an alternative

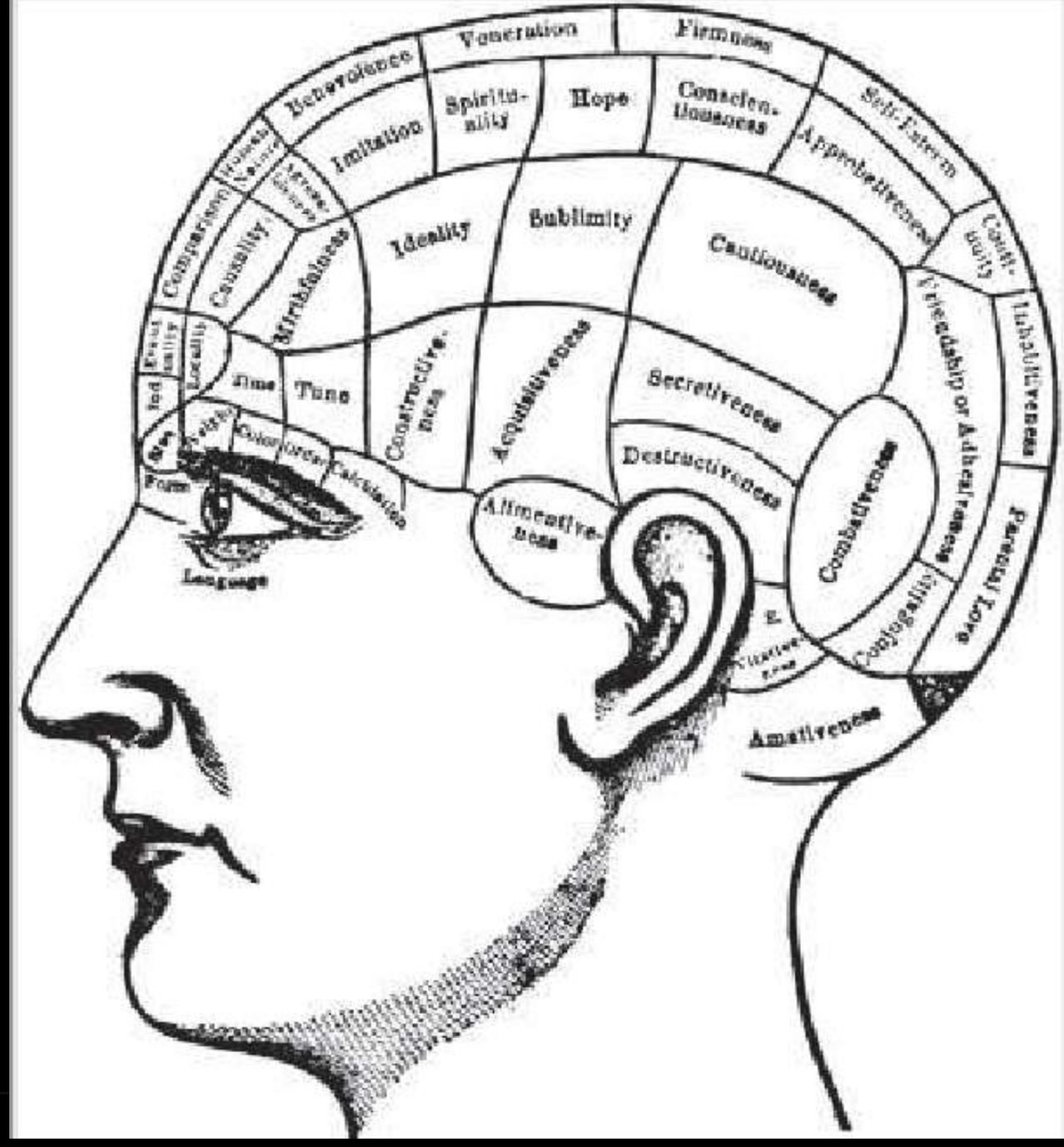
What is the Economy?

The economy is the metabolism of civilization

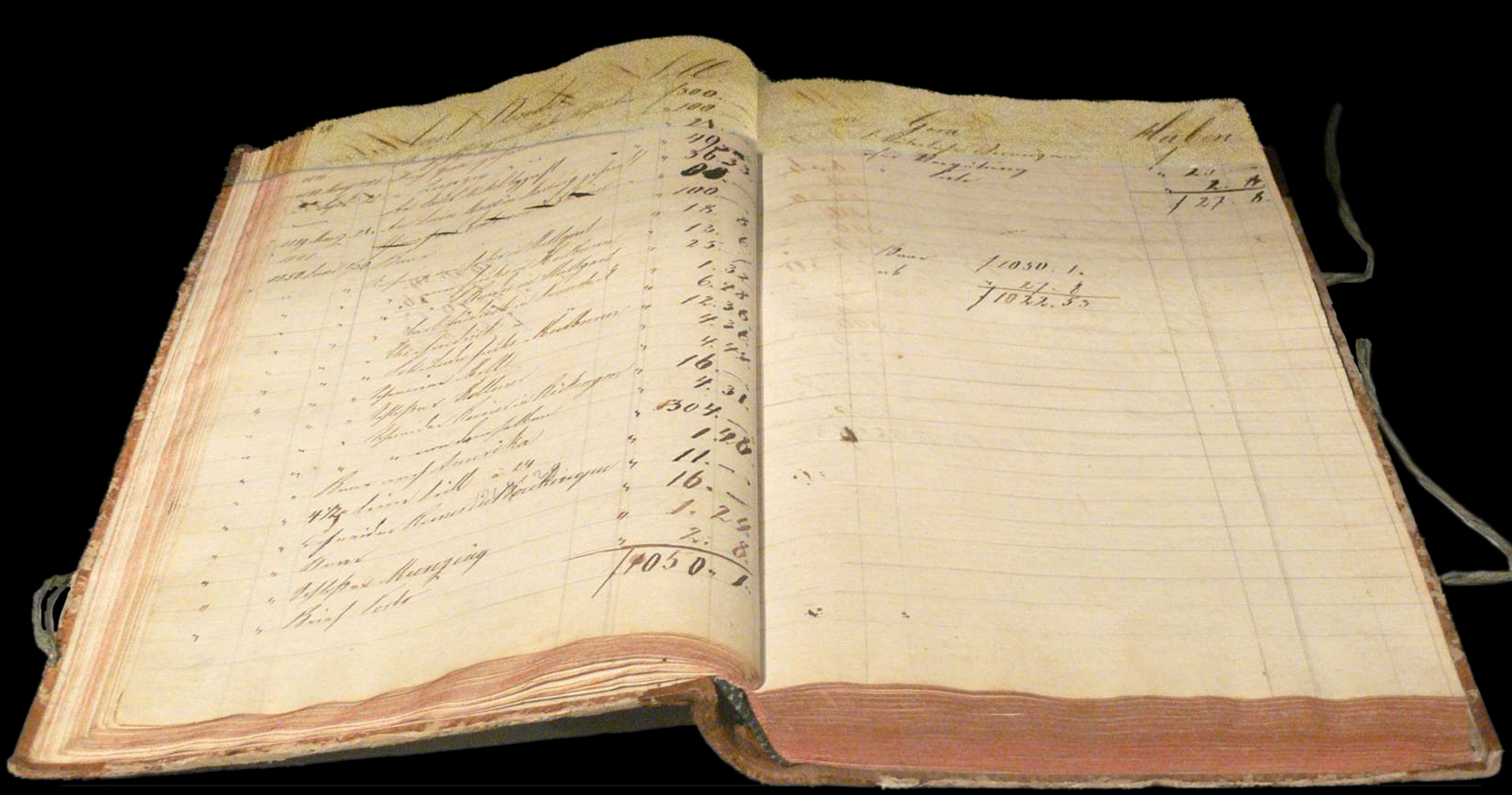


The financial system is like the enteric nervous system





Economics=Accounting+Behaviour

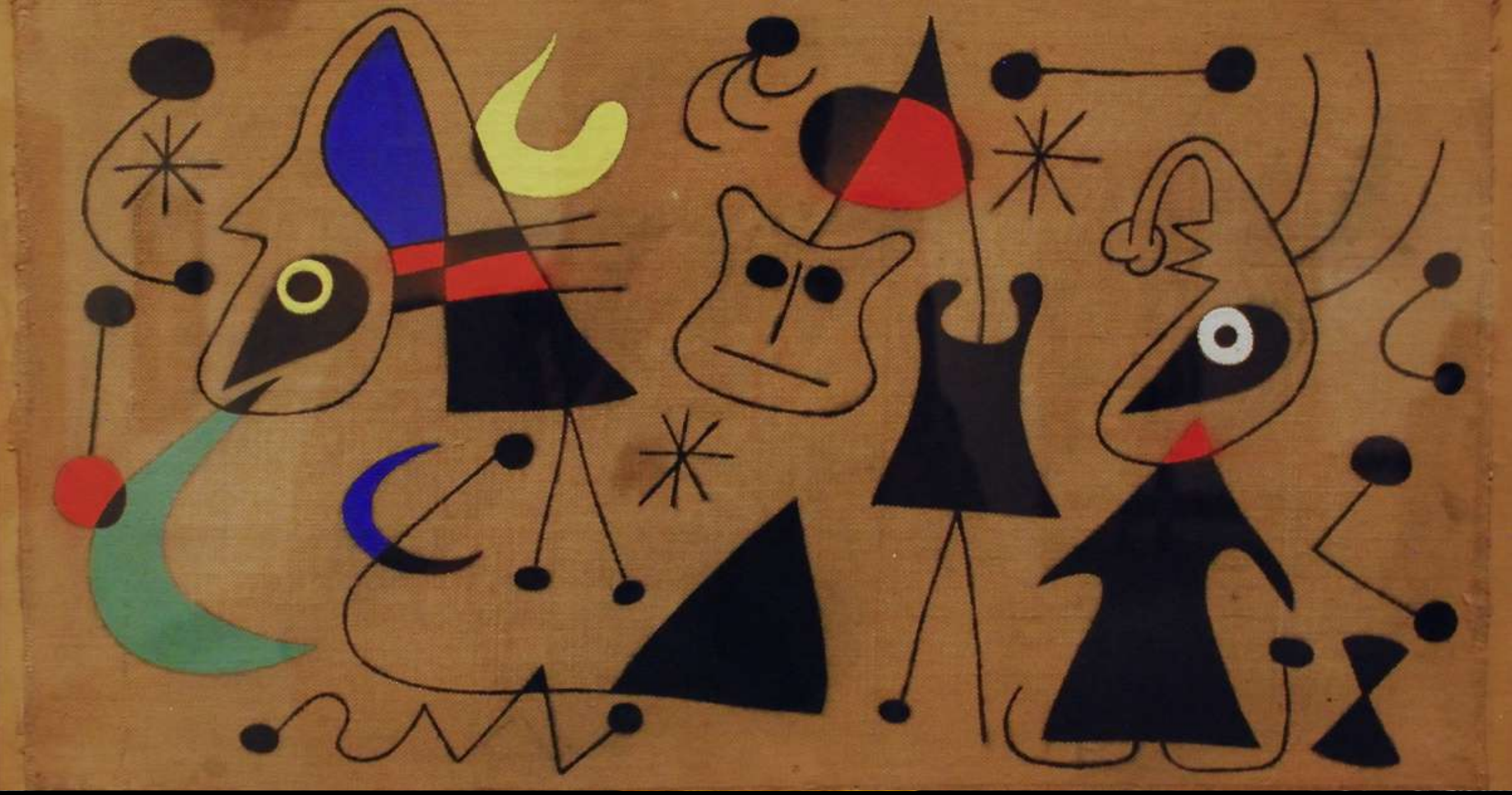


Accounting: Balance sheets are interlinked by transactions and liabilities

The economy is vastly complicated

Behavior is complicated too

Dominant model for behavior is *rational expectations*. Alternatives are now being explored



Complexity economics: Be flexible!
Model behavior directly

People use heuristics + bounded rationality to solve problems

The economy can be simulated

"Standard" complexity economics model:

Assign agents decision making rules or learning algorithms

Simulate collective interactions

Observe economic phenomena

Why does the economy change?

Mainstream economics says the economy changes because of “shocks”

Exogenous Dynamics

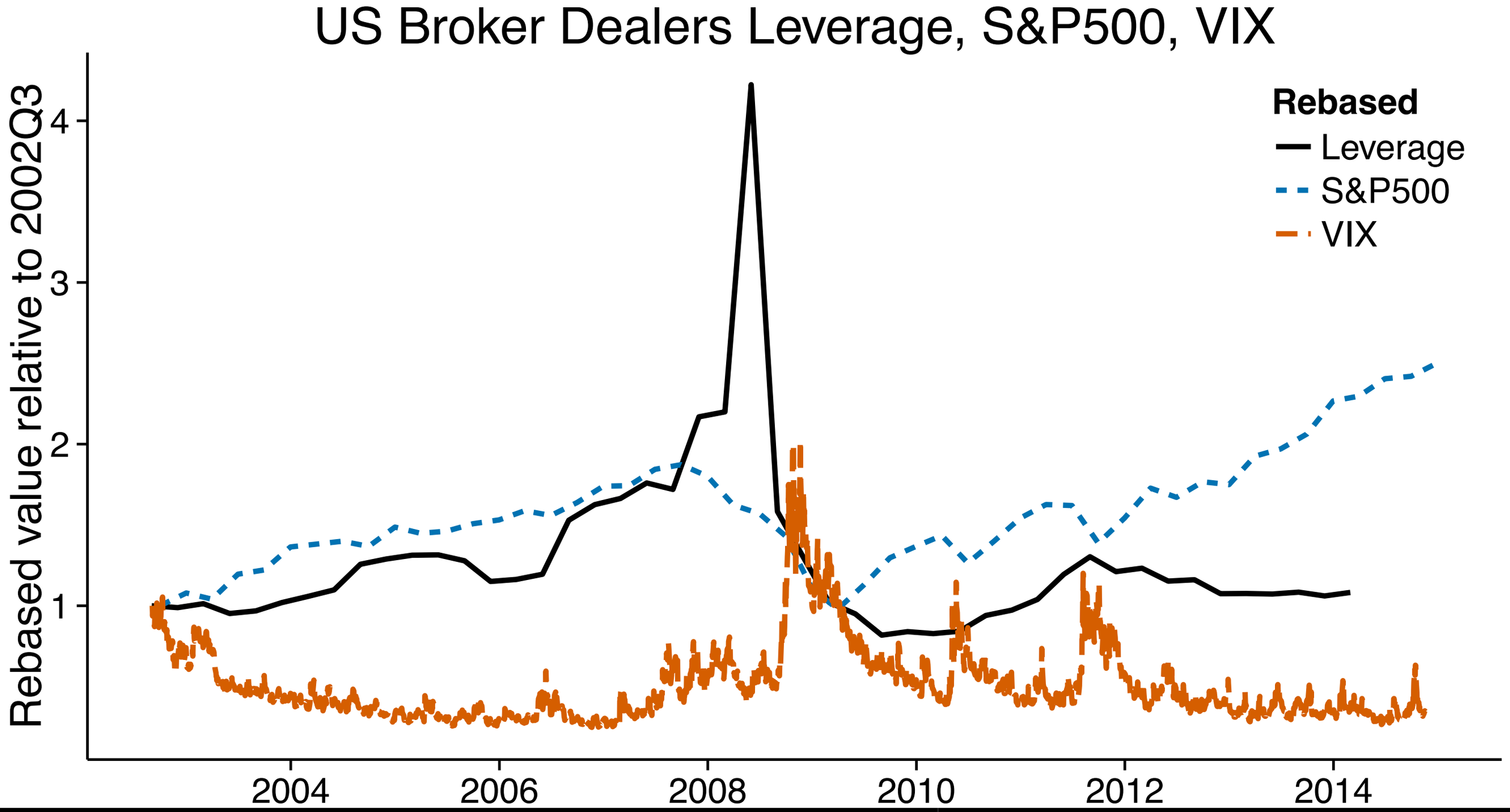
DSGE = rocking horse economy

But the weather changes all by itself
Endogenous Dynamics

The economy also changes by itself

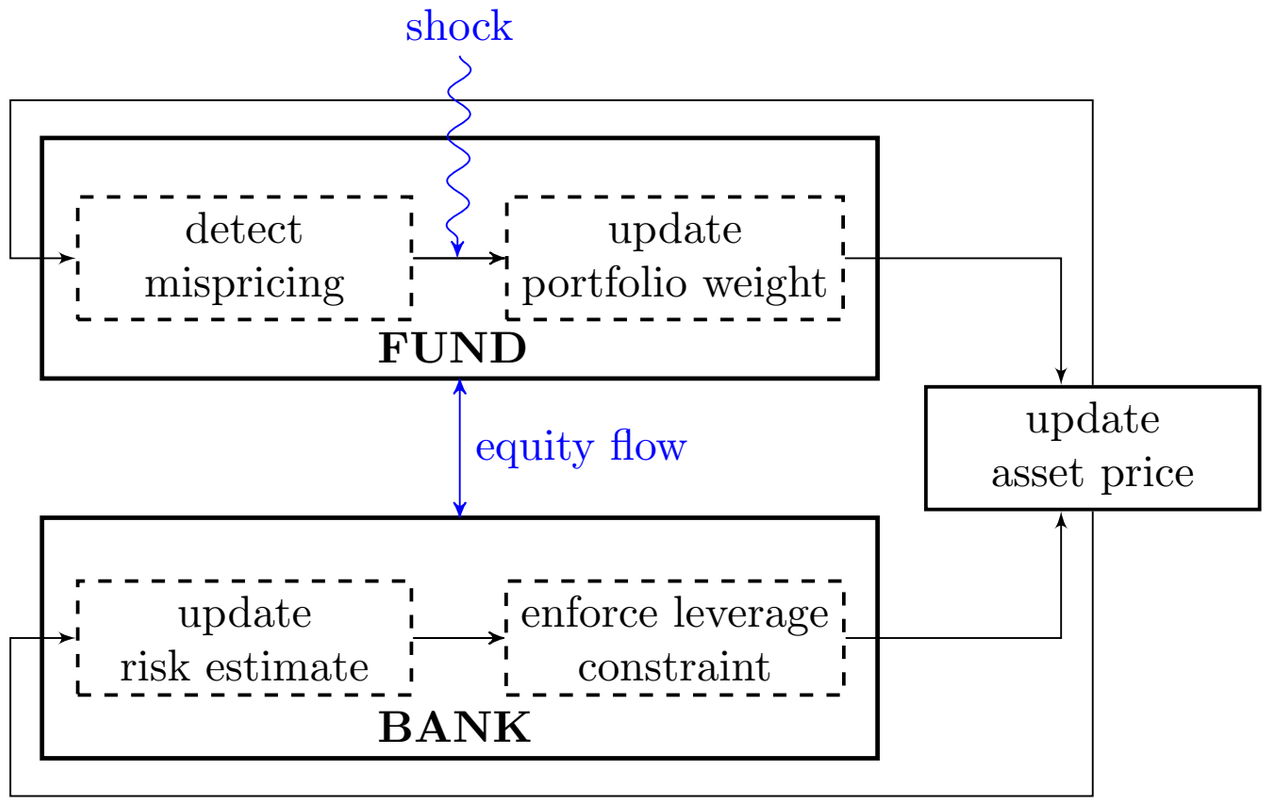
In economics the future strongly influences the present.
Rational utility maximizers are unduly static.

Bounded rationality naturally creates endogenous dynamics



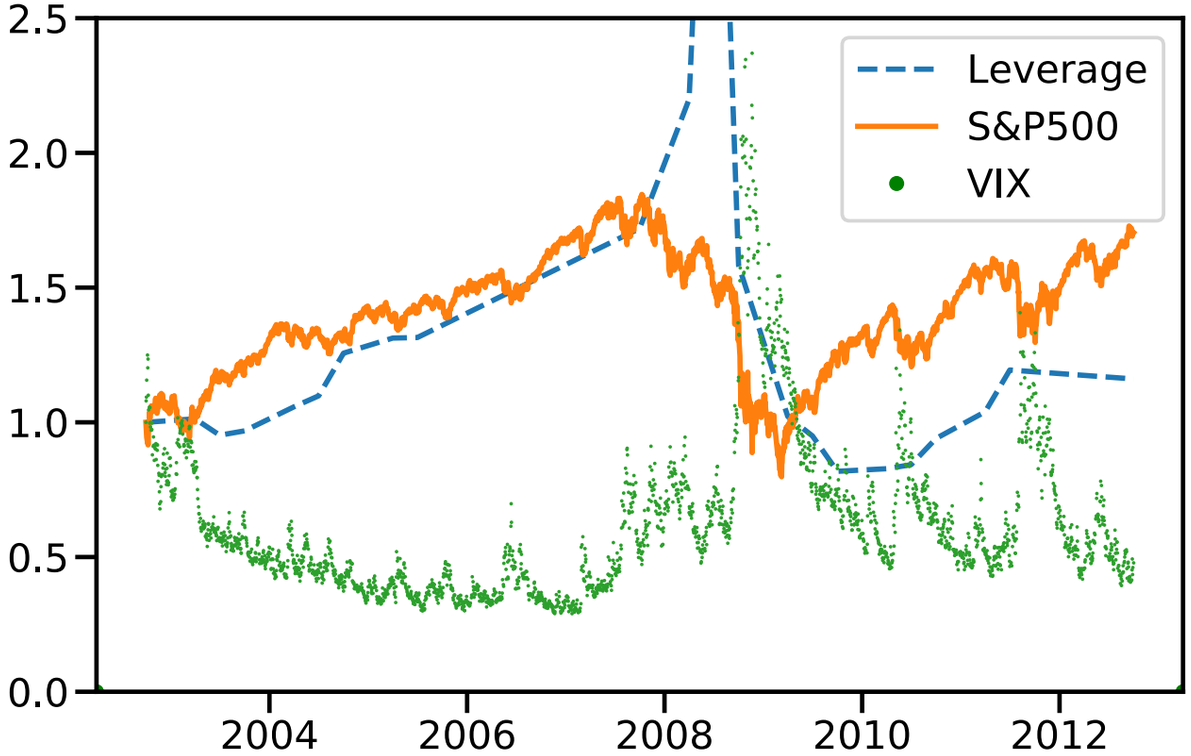
Cause of Crisis of 2008?

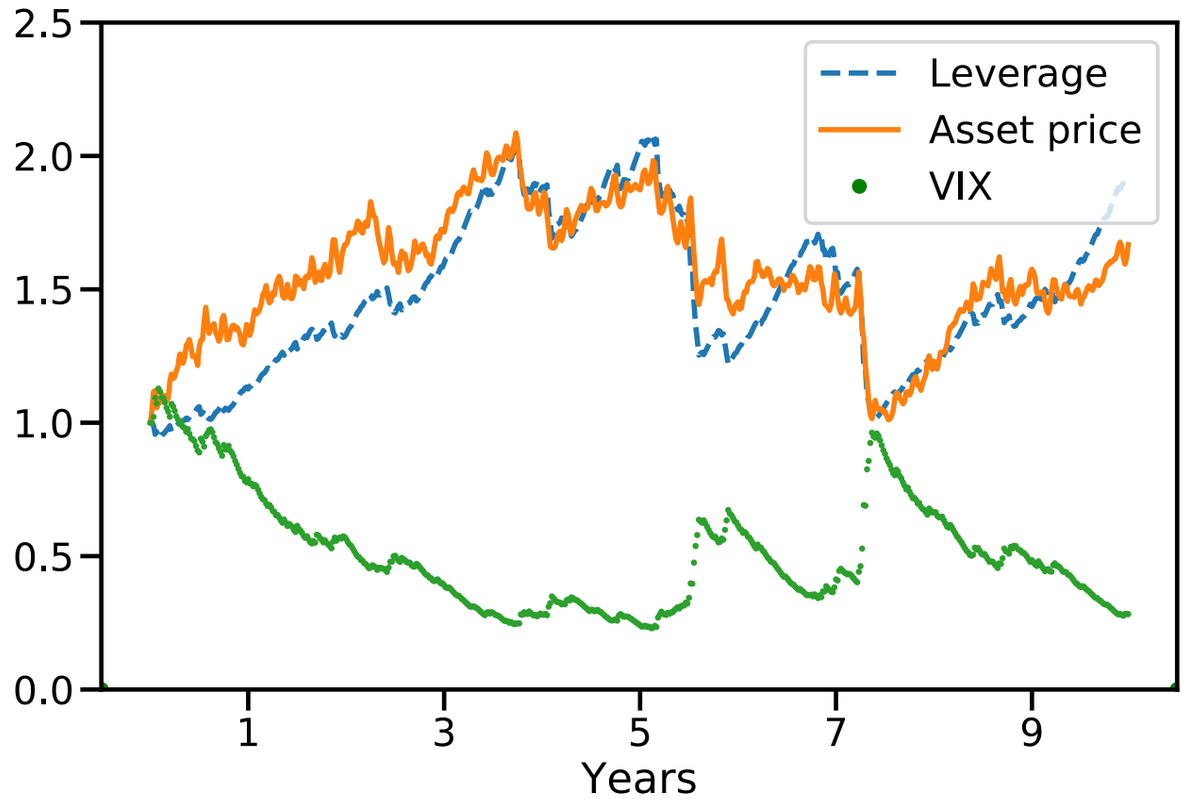
- Two agents: bank and fundamentalist
- One risky asset + cash
- Four assumptions:
  - Bank uses exponential moving average of historical volatility to estimate expected volatility
  - Basel II risk management (VaR) sets leverage target
  - Price formation (supply = demand) (Increasing leverage target => buying => price of asset rises)
  - Fundamentalist buys undervalued asset & vice versa



The Basel Leverage Cycle Model

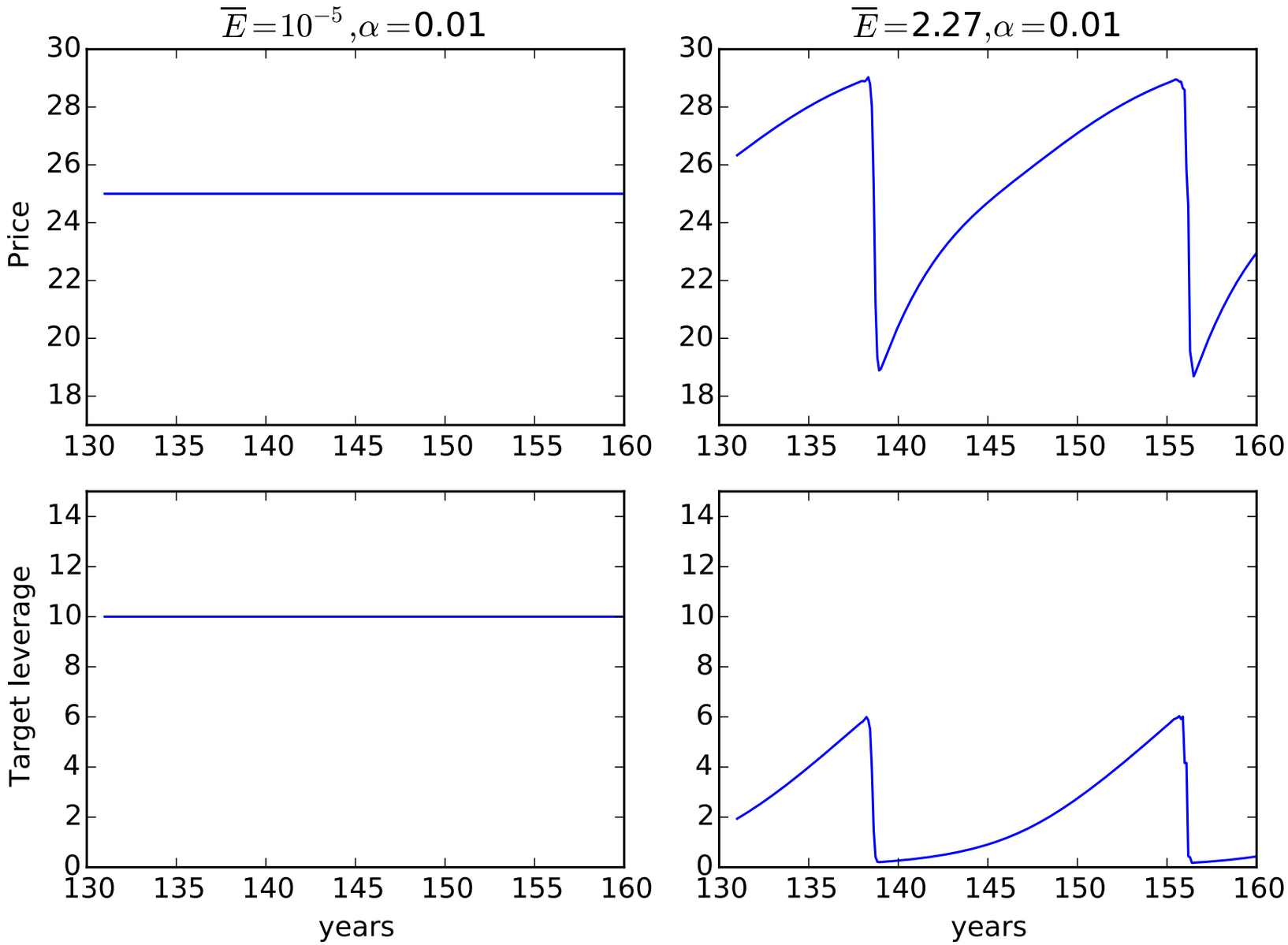
Aymanns and Farmer, 2015; Aymanns, Caccioli, Farmer, Tan, 2016





Reality

Model



Small banking sector

Large banking sector

Price and leverage change, even without any external shocks Bifurcation is sudden!

Standard macro model with bounded rationality

Yuki Asano, Jakob Kolb, JDF, Jobst Heitzig

- Standard RCK model: Rational, representative household chooses savings rate to maximize discounted consumption
- Invests savings in representative firm
  - compromise between consumption and investment
- Our version: Heterogeneous households have social network. At intermittent intervals of average length tau, each copies savings rate of neighbor with highest consumption.

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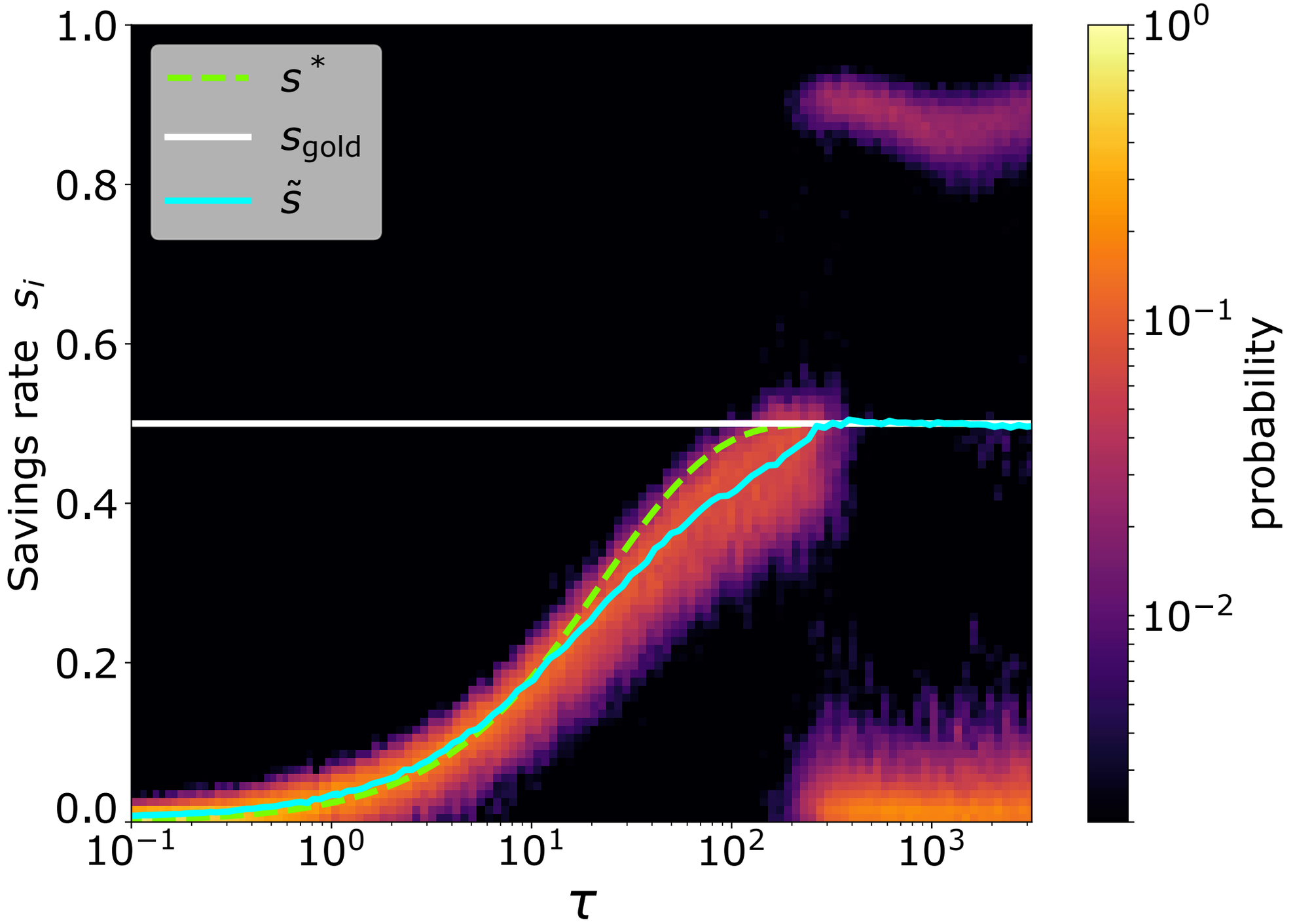
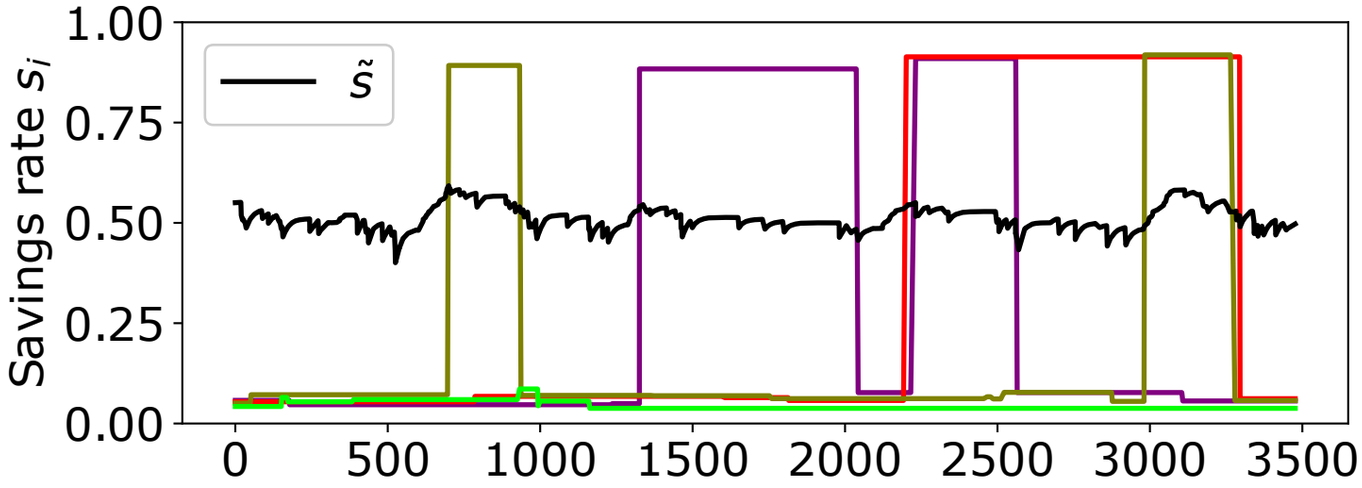
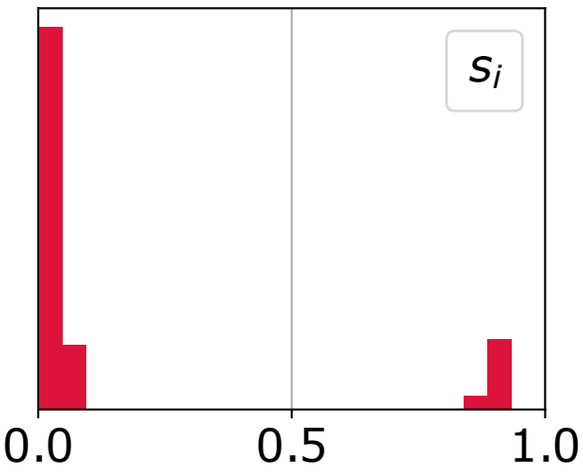
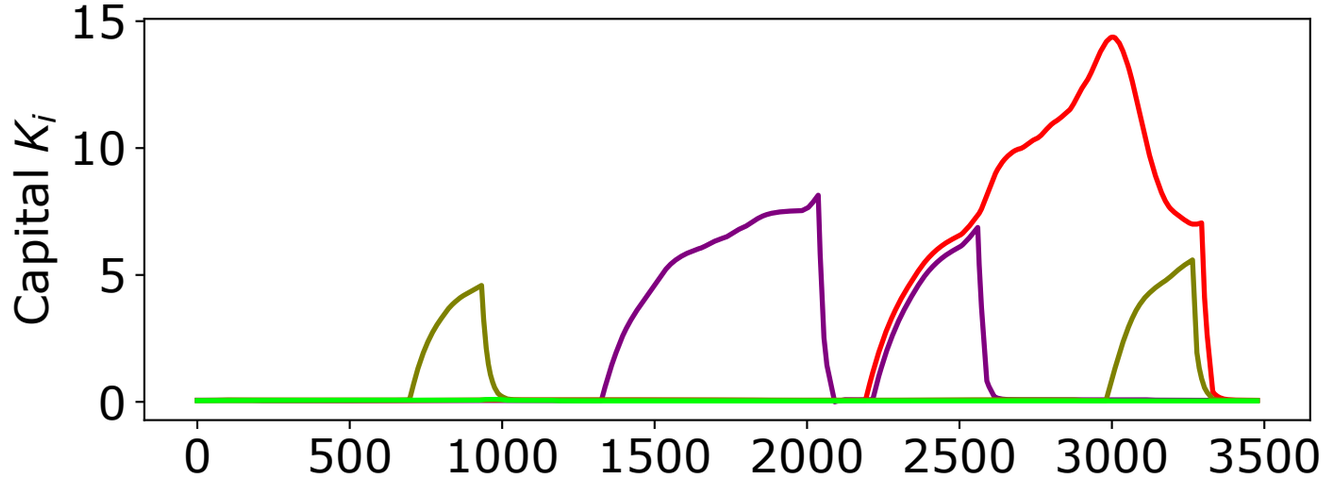


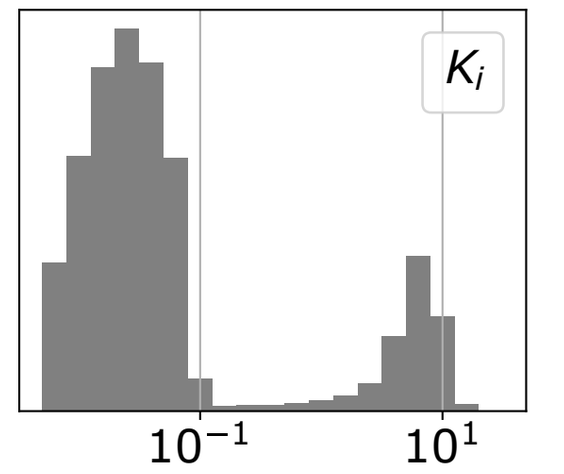
Time evolution

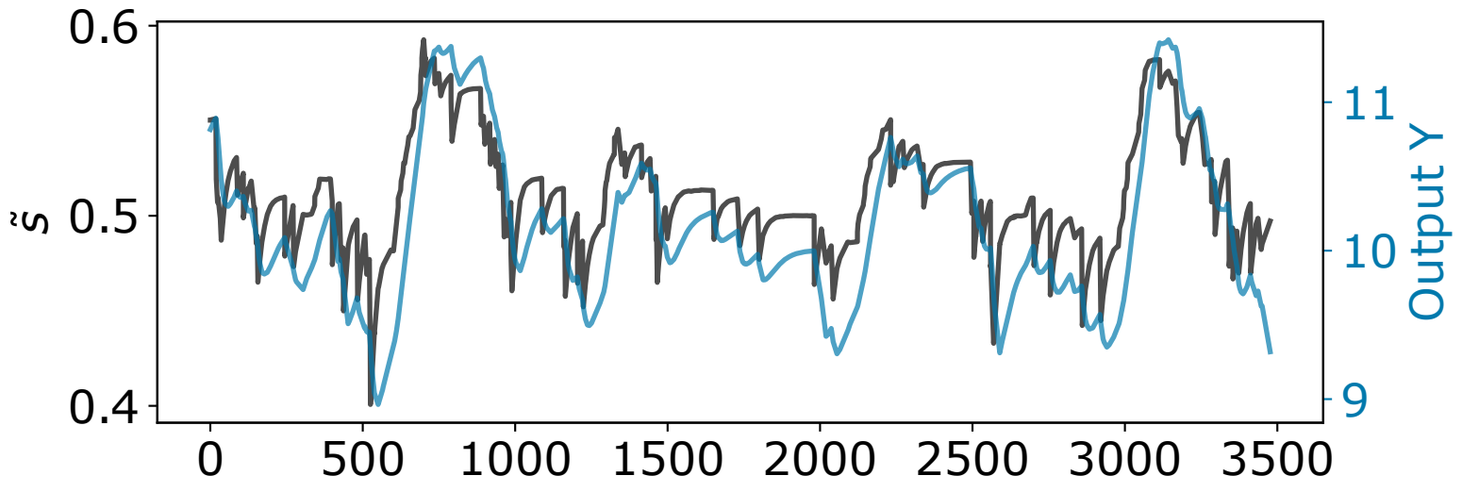
Histograms

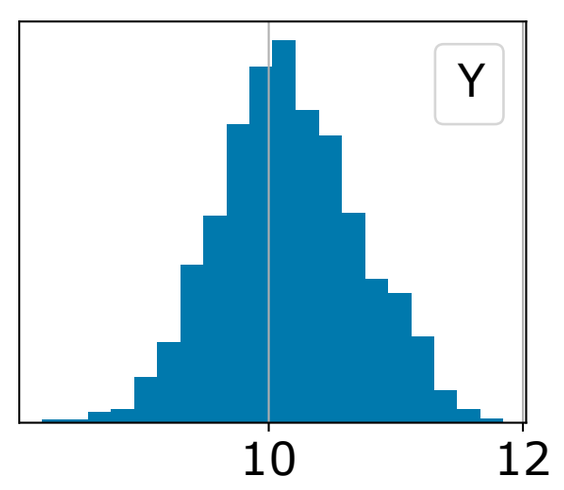


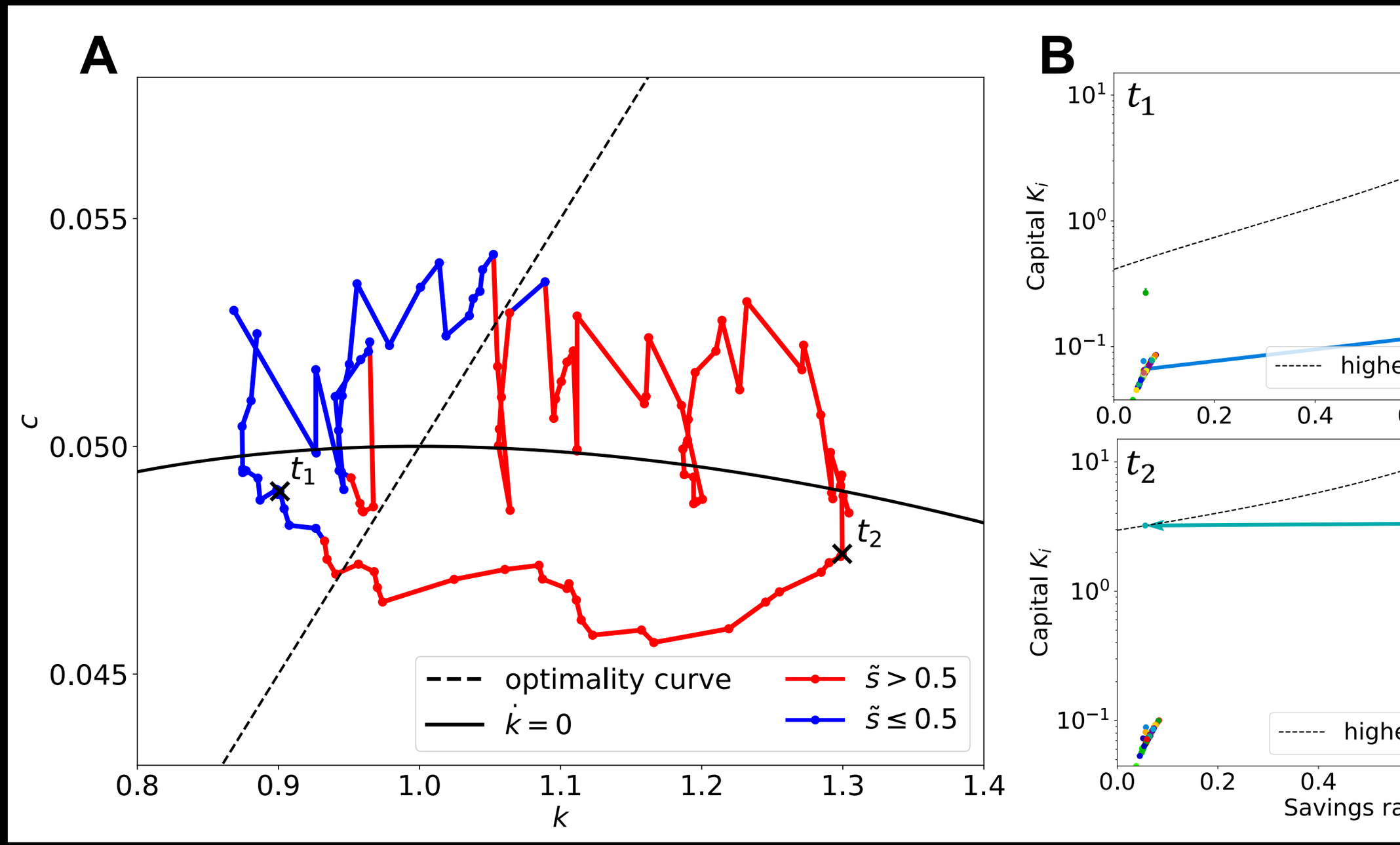












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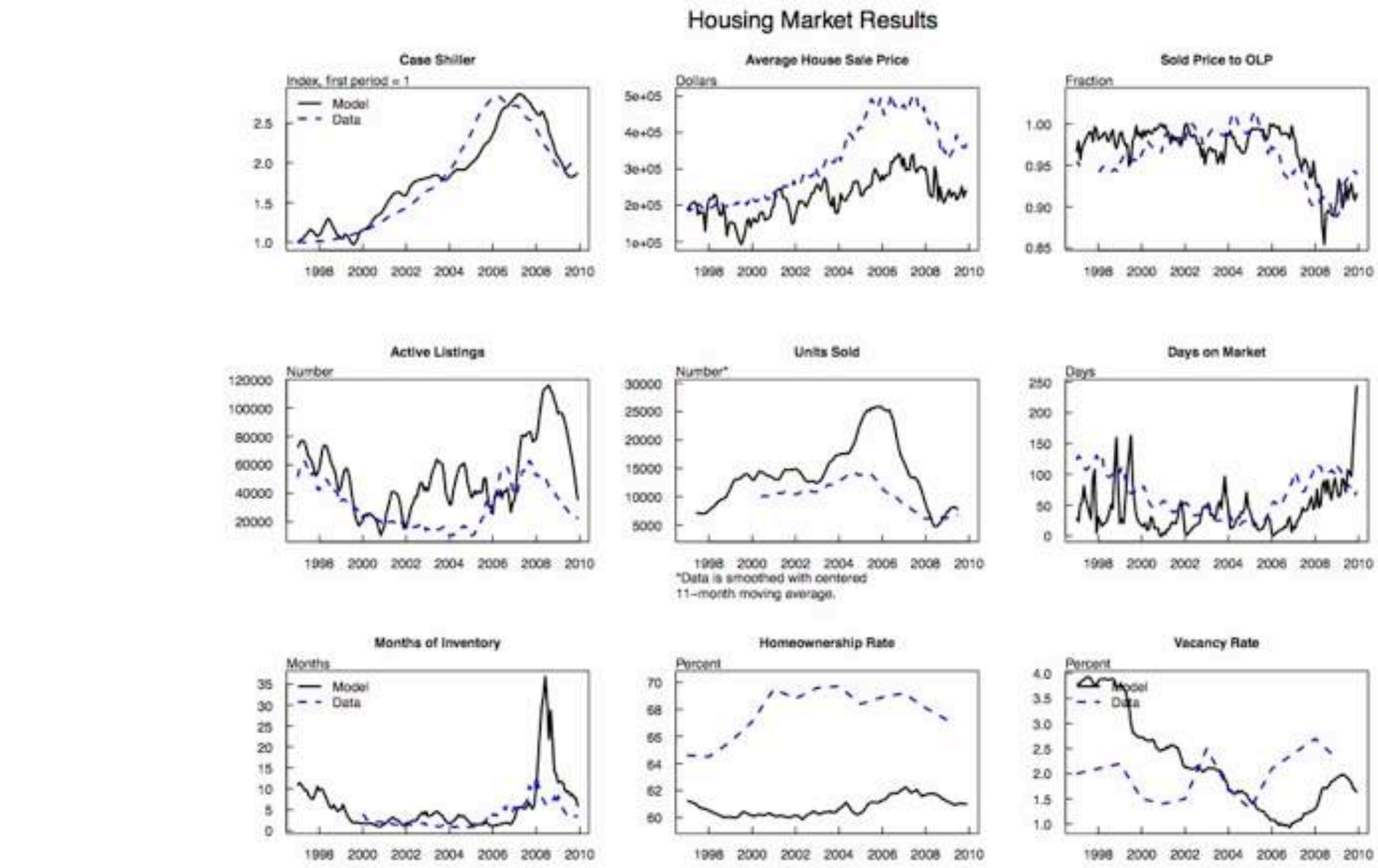
EURACE macro model. Endogenous business cycles are typical for ABMs.

Dawid, Harting, van der Hoog, Neugart (2018)



Simulation of Washington DC Housing Market

Axtell, Carella, Farmer, Geanakoplos, Goldstein, Howitt and others.

Economic Forecasting with an Agent-based Model

Sebastian Poledna[a,b,f], Michael Gregor Miess[e,a,c,g], Cars Hommes[d,h,i,*]

[a] *International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria*
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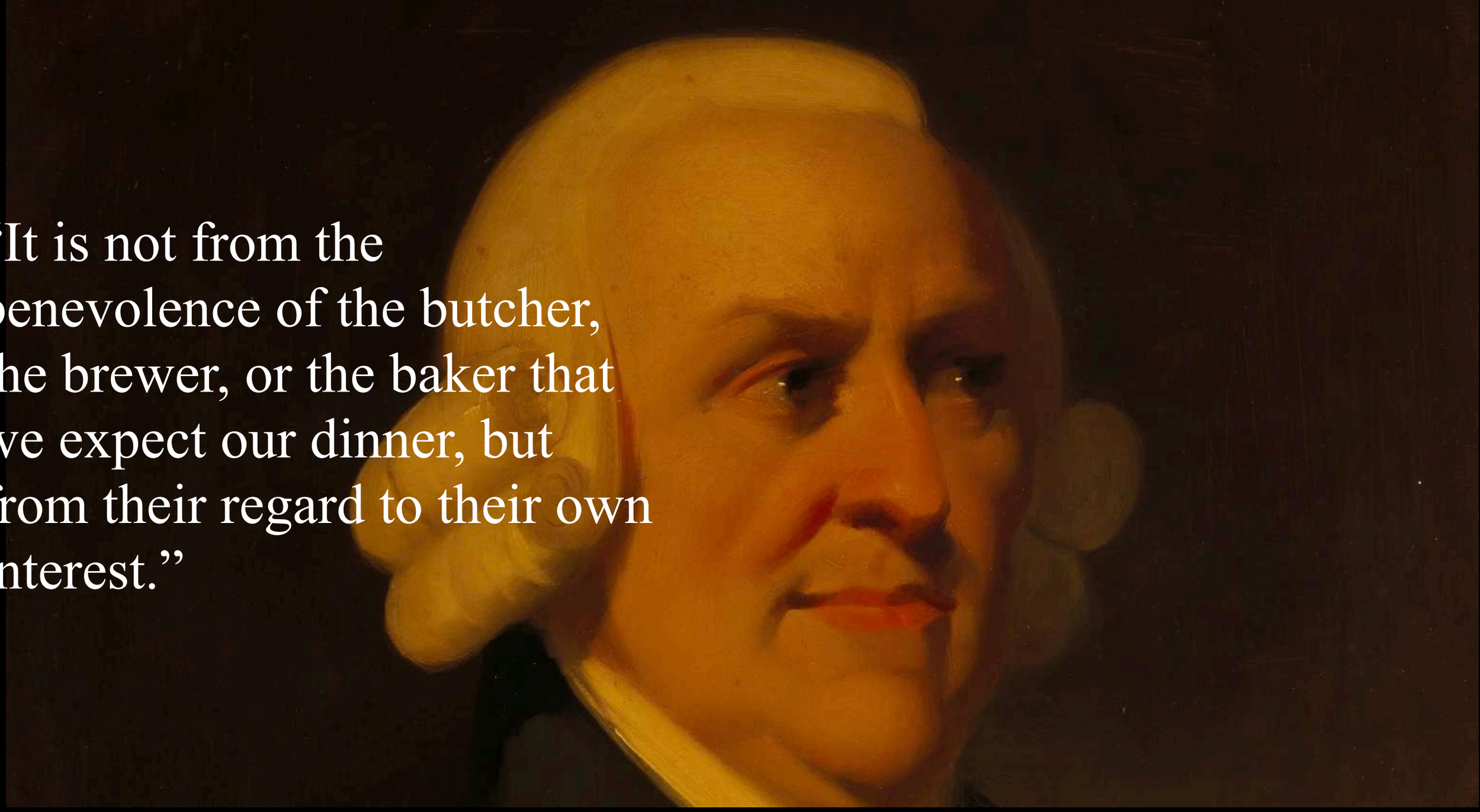
Abstract

We develop the first agent-based model (ABM) that can compete with benchmark VAR and DSGE models in out-of-sample forecasting of macro variables. Our ABM for a small open economy uses micro and macro data from national and sector accounts, input-output tables, government statistics, census and business demography data. The model

And hot off the press…

The economy is an ecology of specialists



Adam Smith, Wealth of Nations, 1776.

Unemployment

H

L

Food preparation & serving

Arts, design, entertainment, sports & media

Personal care & service

Community & social service

Healthcare support

Office & administrative support

Sales & sales related

Healthcare practitioners & technical

Protective service

Education, training & library

Legal

Management, business & financial

Transportation & material moving

Life, physical & social science

Architecture & engineering

Production

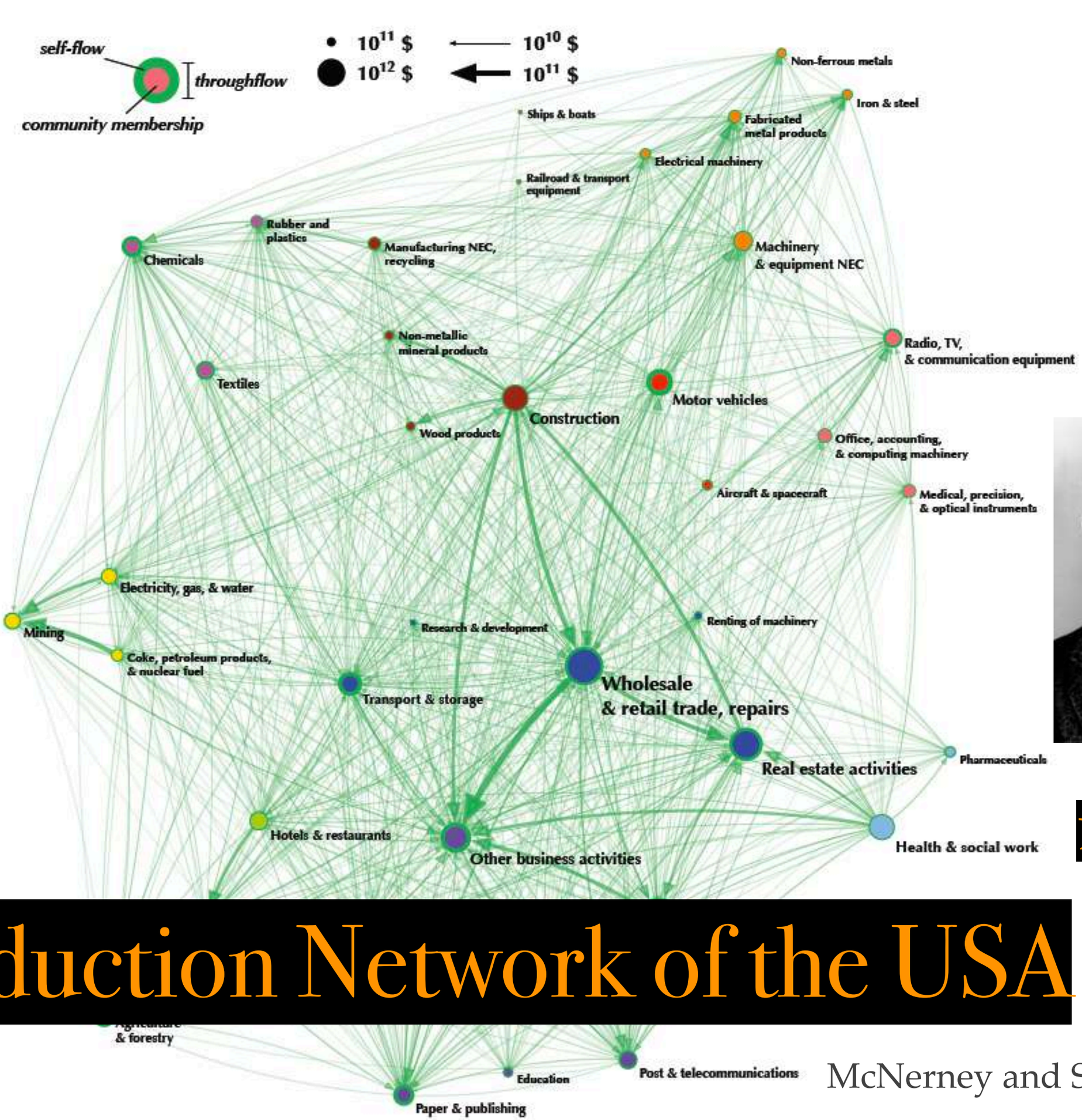
Computer science & engineering

Installation, maintenance & repair

Construction & extraction

Unemployment

Physical supply chain of a laptop

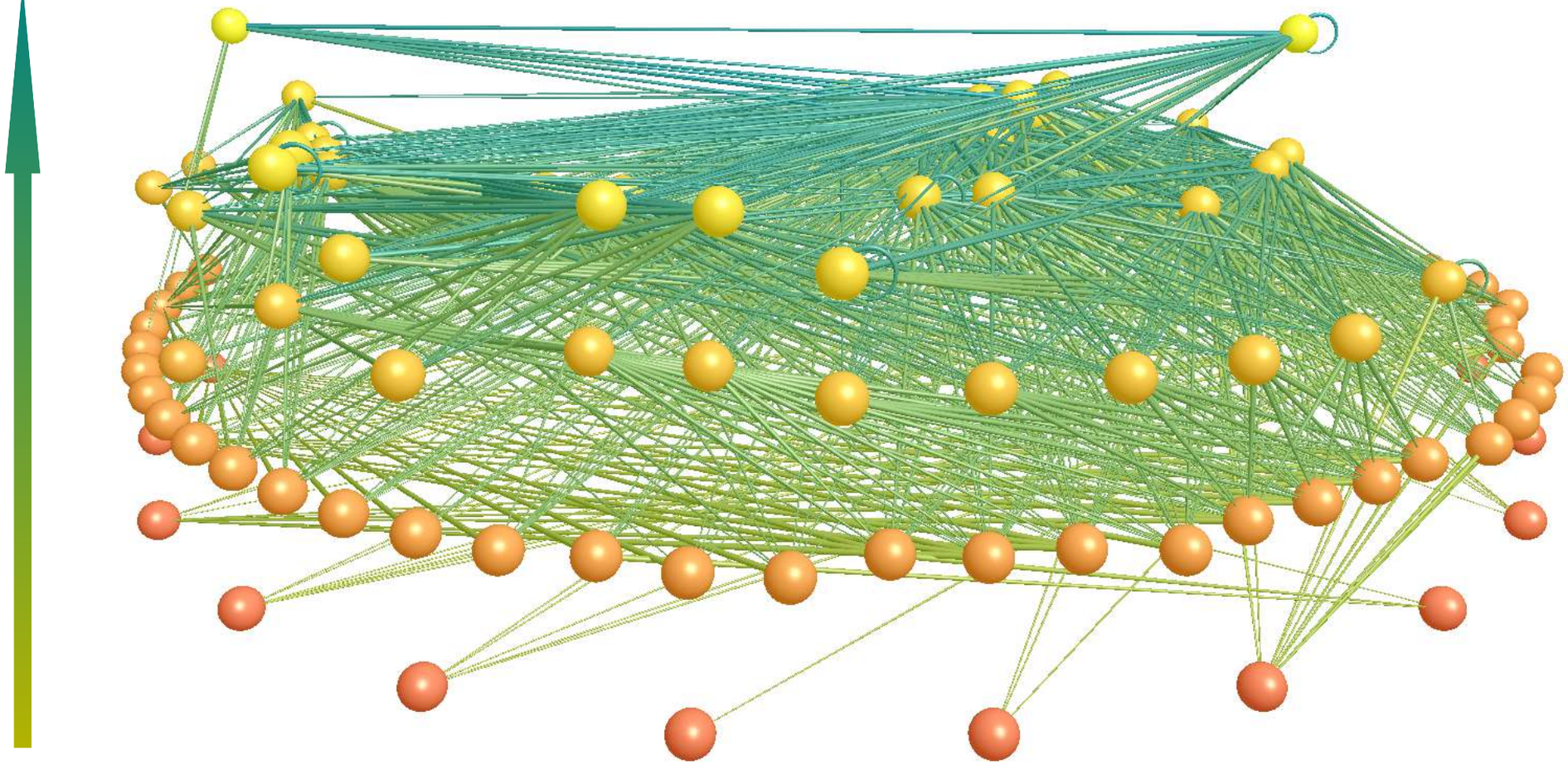


Wassily Leontief

Production Network of the USA

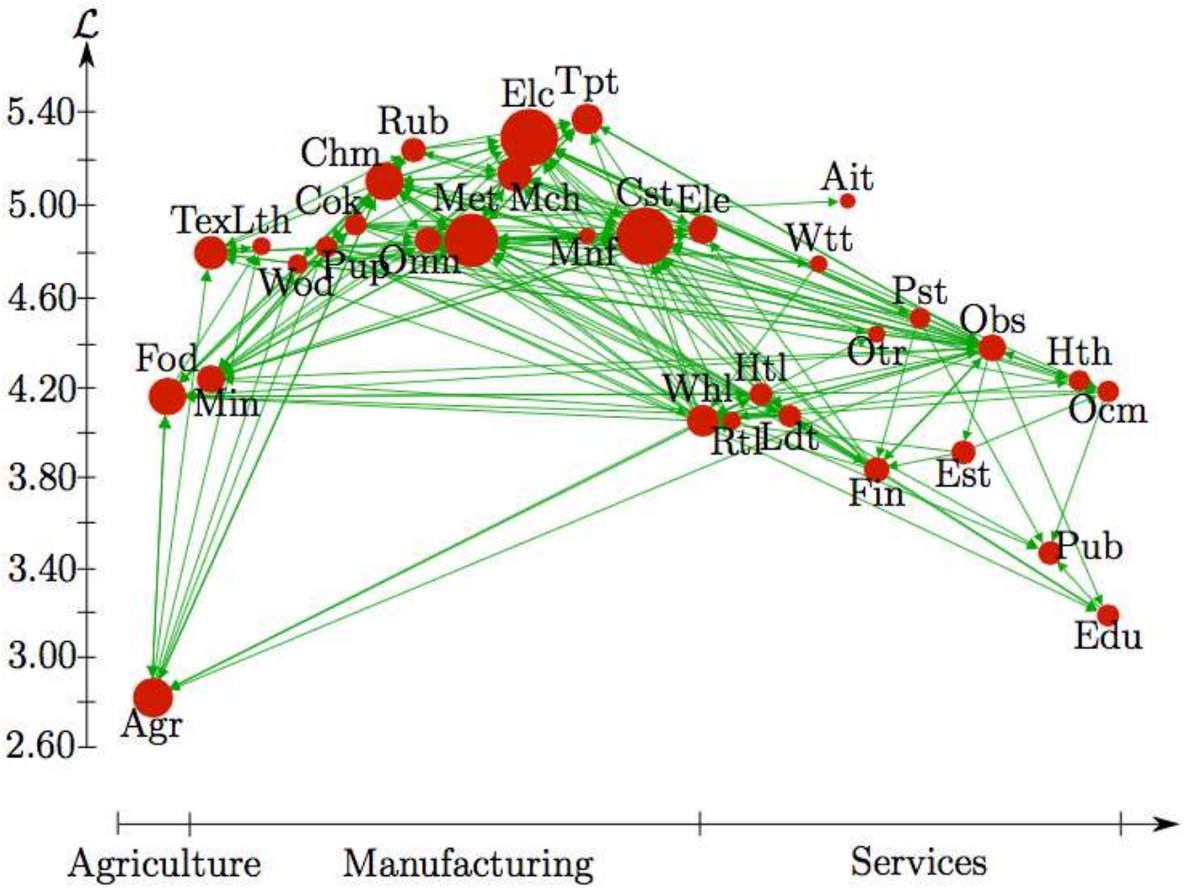
McNerney and Silverberg

997 Feeding Links among 92 Taxa: 10 Basal, 72 Invertebrates, 10 Fishes

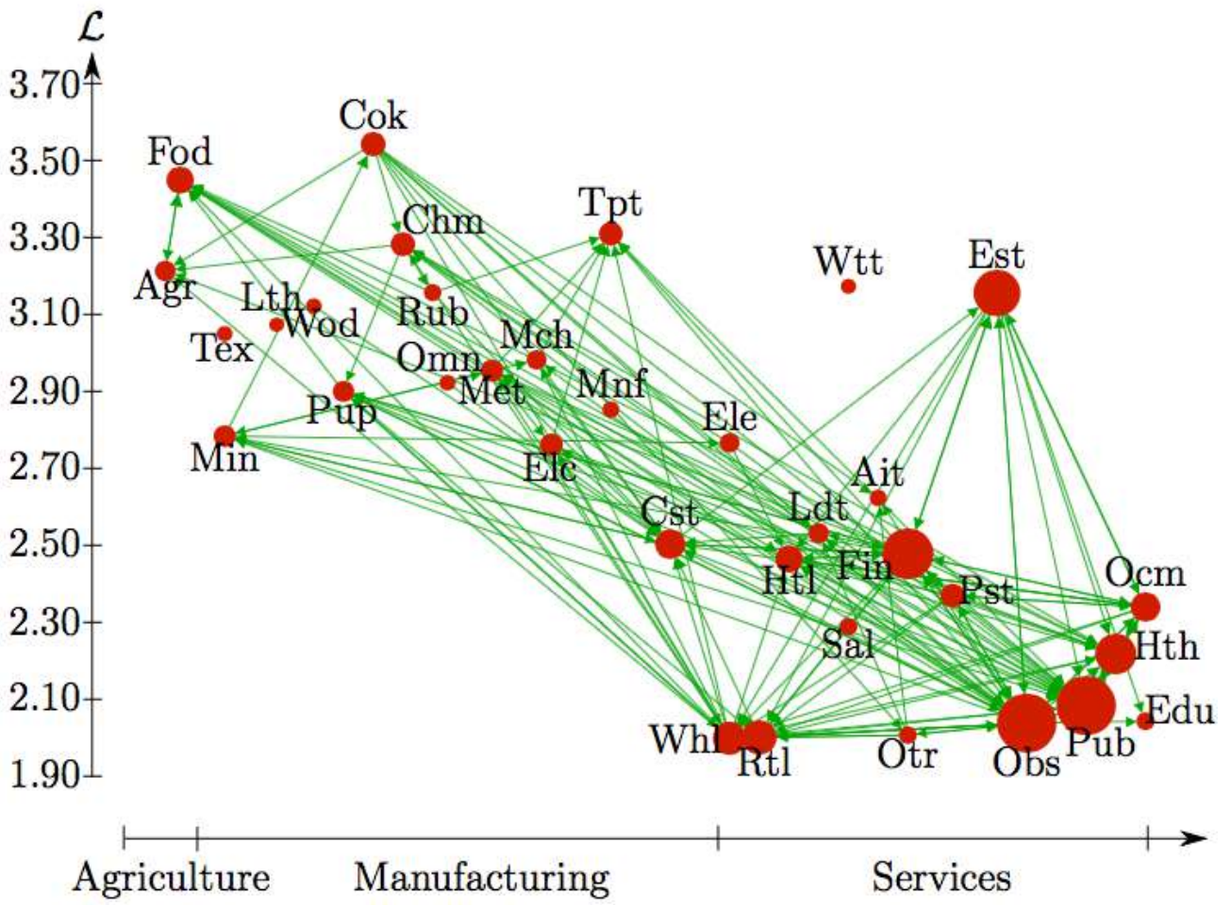


Food Web of Little Rock Lake, Wisconsin

Jennifer Dunne



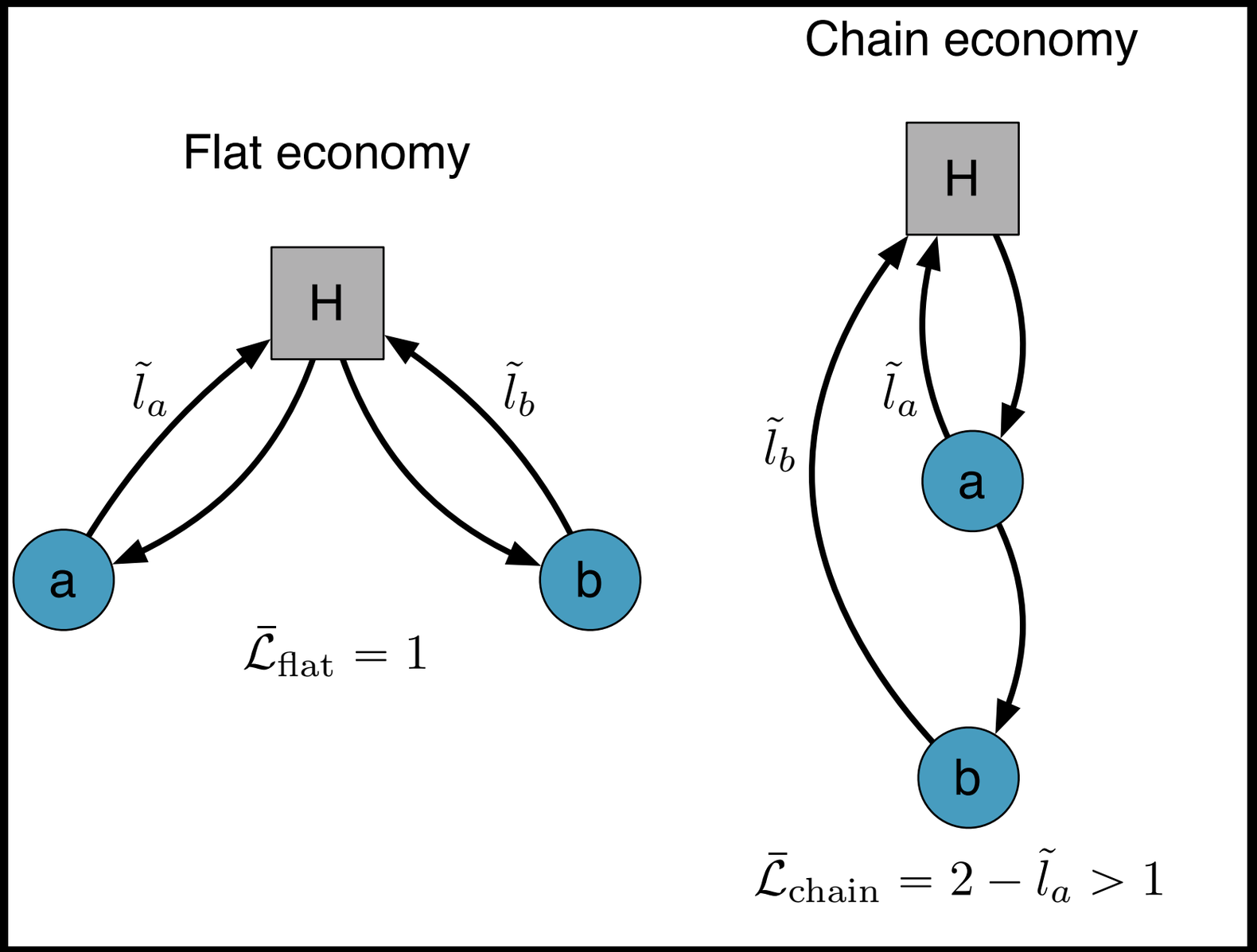
China



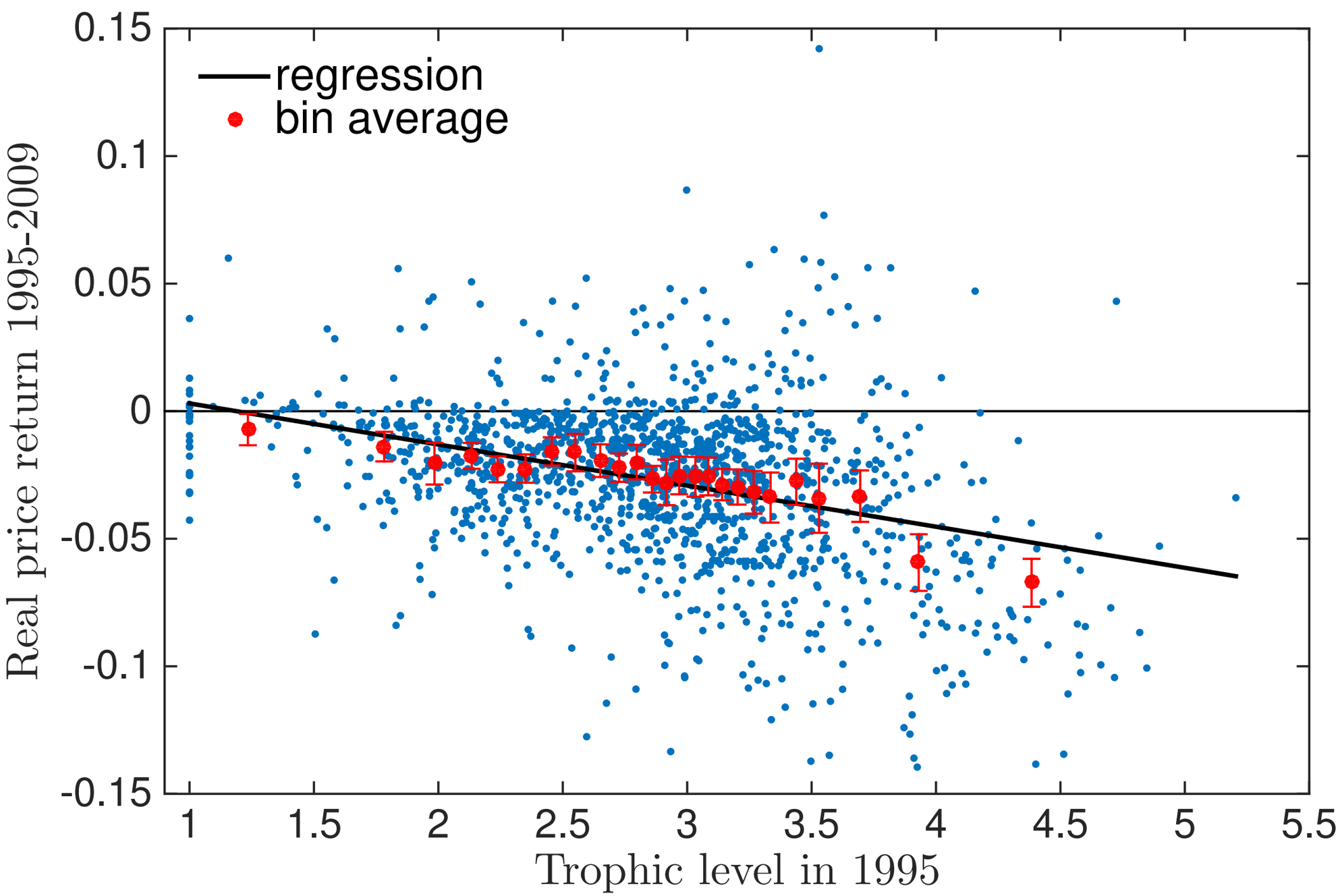
USA

Trophic structure of production

Division of labor implies division of innovation



Chain economy amplifies improvements multiplicatively

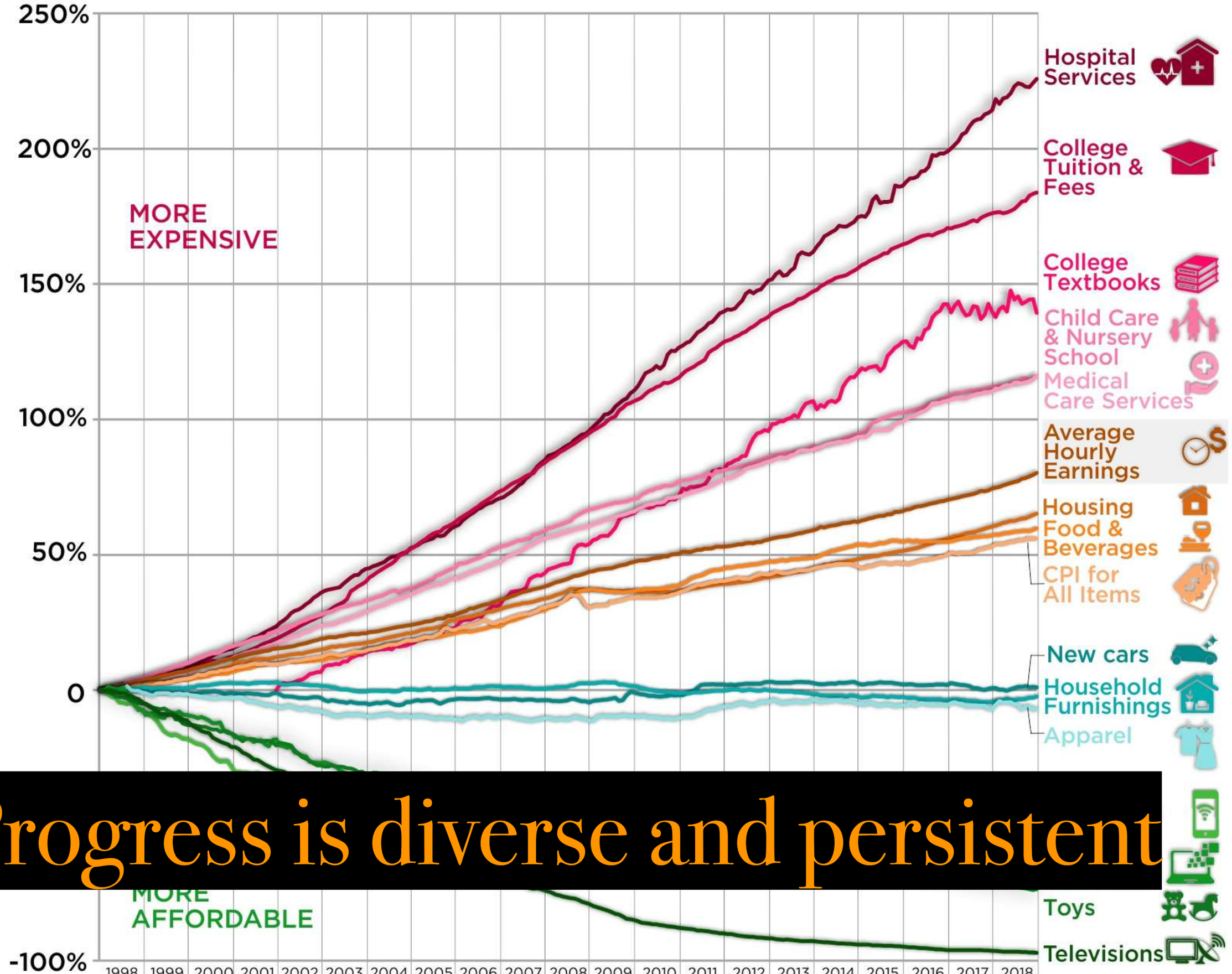


Trophic level predicts economic growth

McNerney, Savoie, Caravelli, Carvalho and Farmer

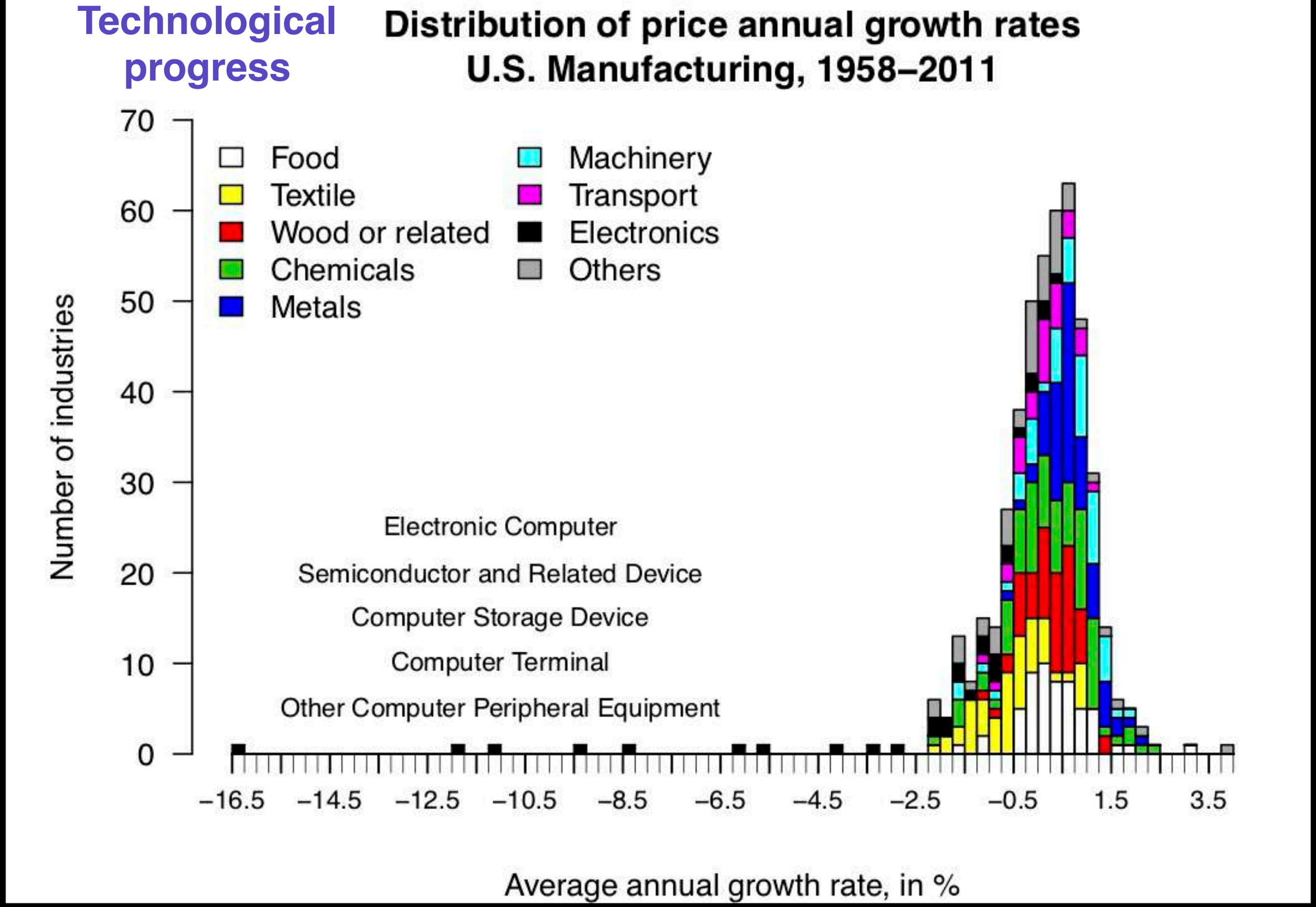
20 Years of Price Changes in The United States

Selected Consumer Goods & Services, Wages (January 1998 to December 2018)



Progress is diverse and persistent

Technological progress



Thanks to Francois Lafond and Jangho Yang

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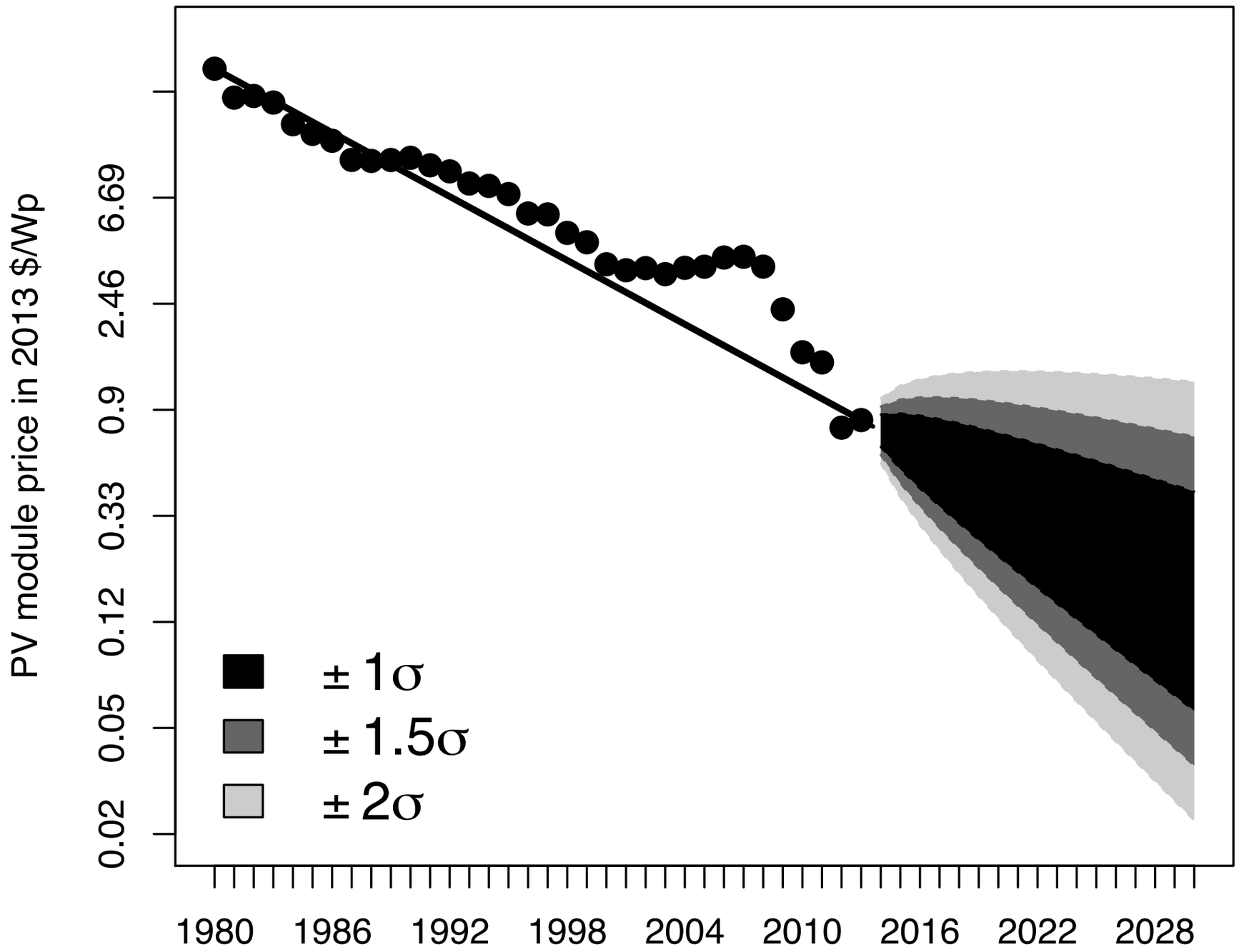
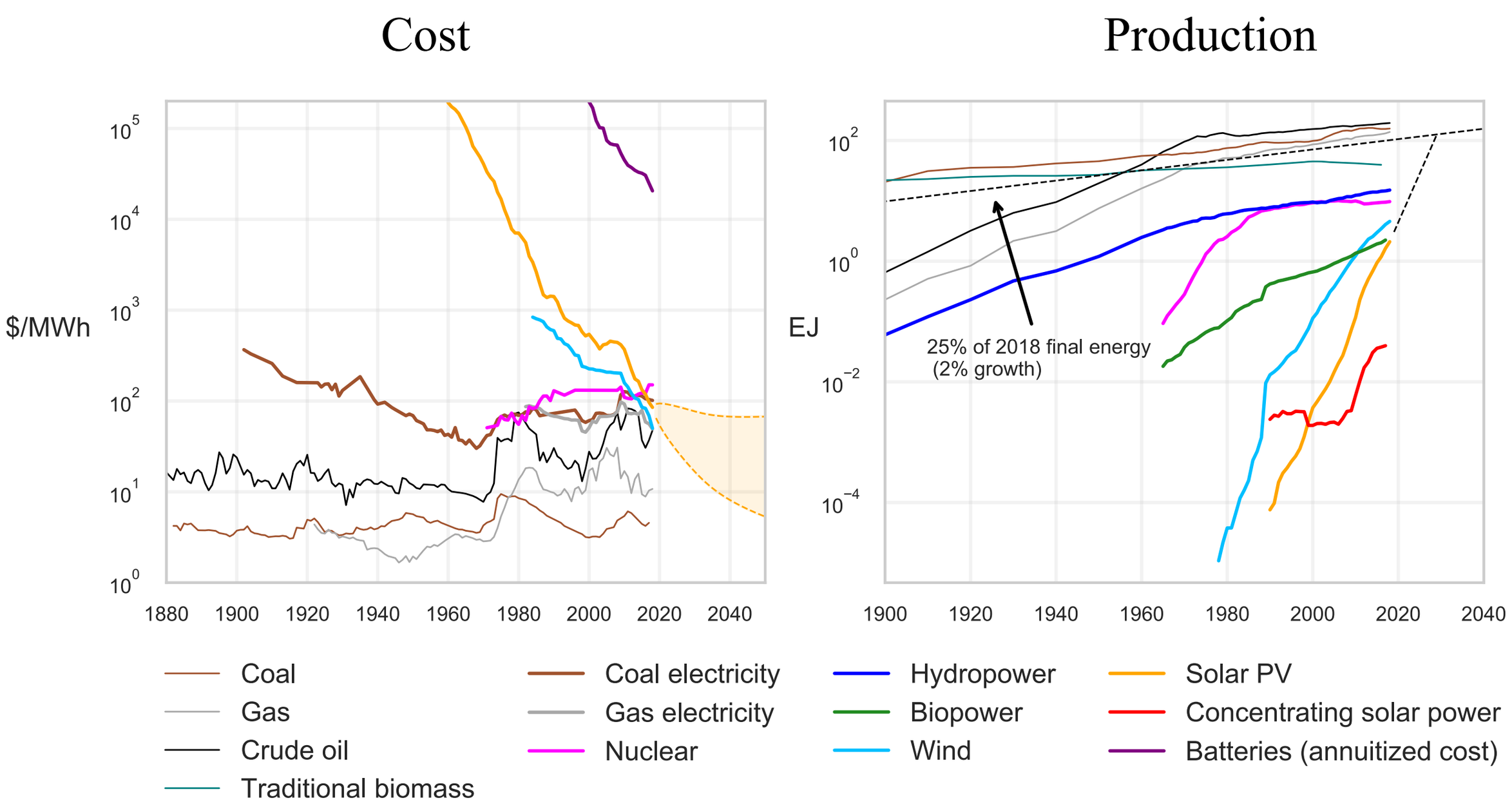


Can use this to forecast prices of technologies

Farmer and Lafond, 2016, Lafond et al. 2018

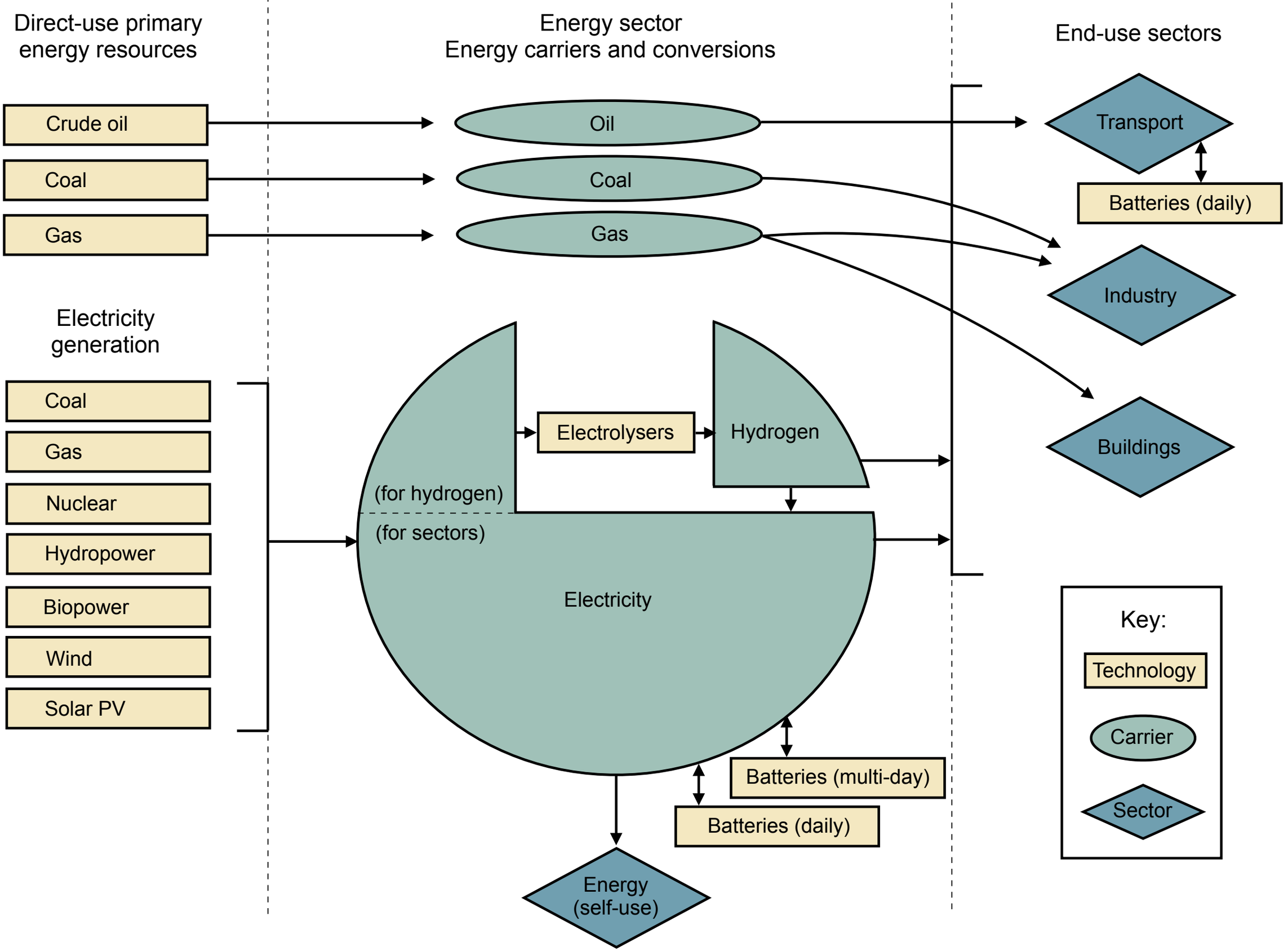
What about Climate Change?

Bill Nordhaus says optimal warming is 3.5 degrees…



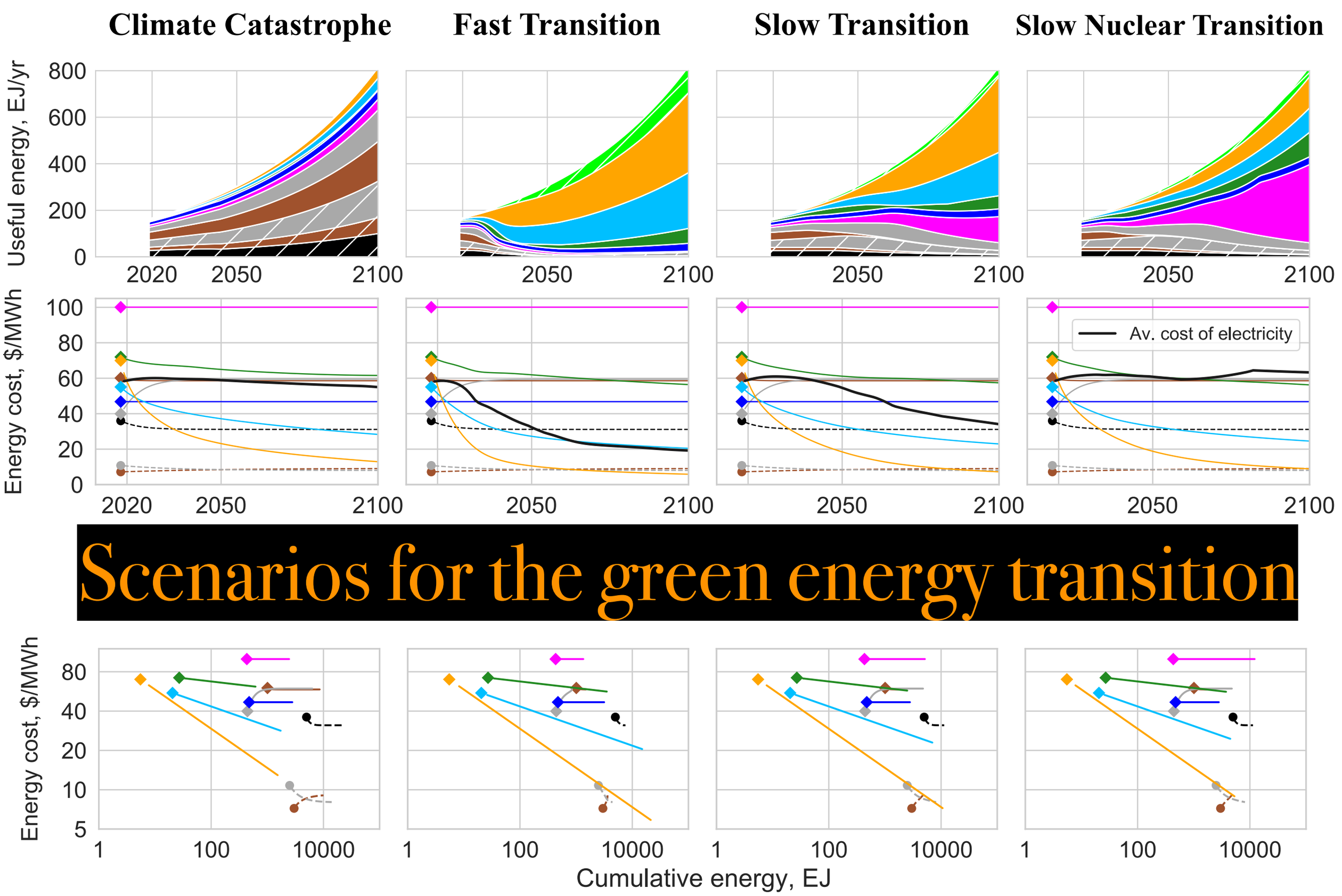
Prices and production of energy technologies

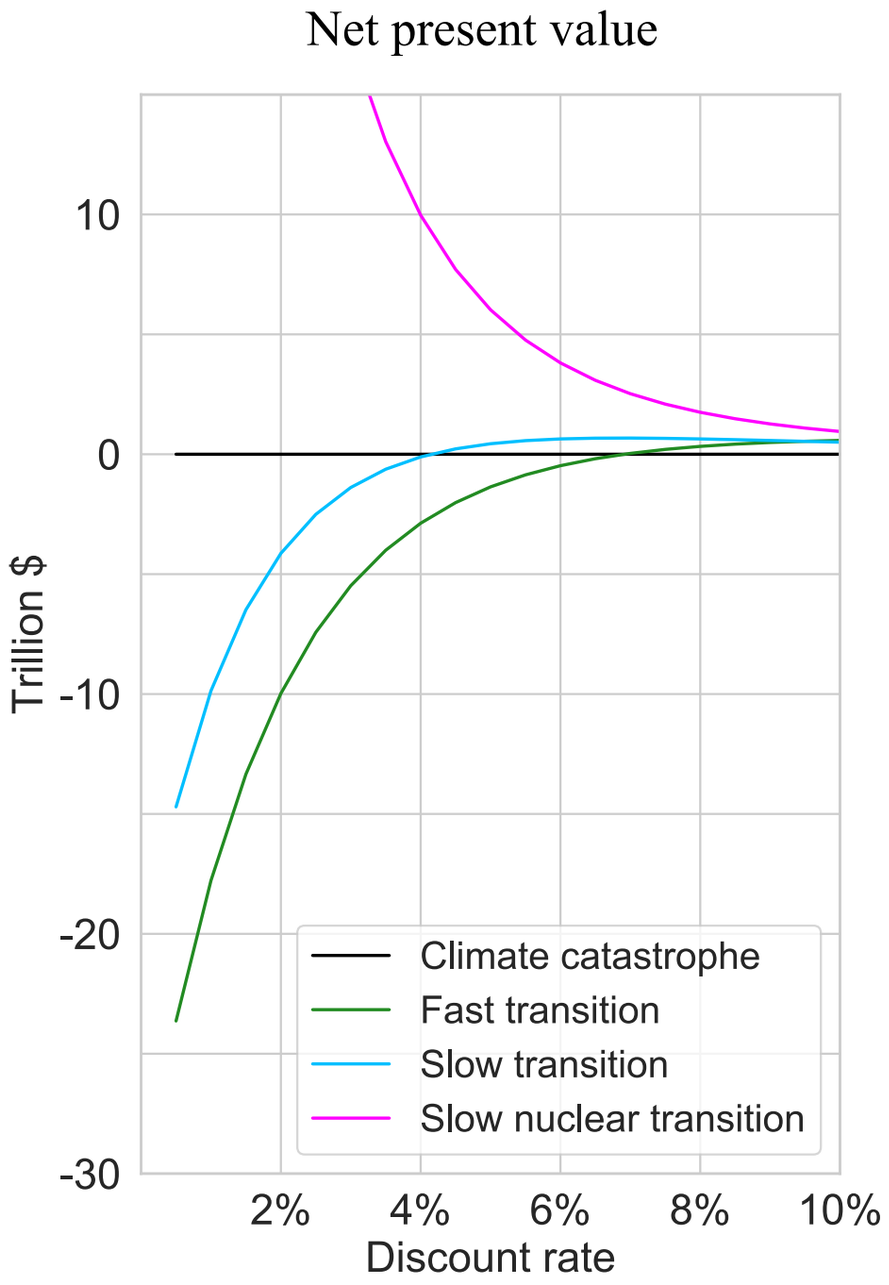
Way, Mealy and Farmer, 2020.

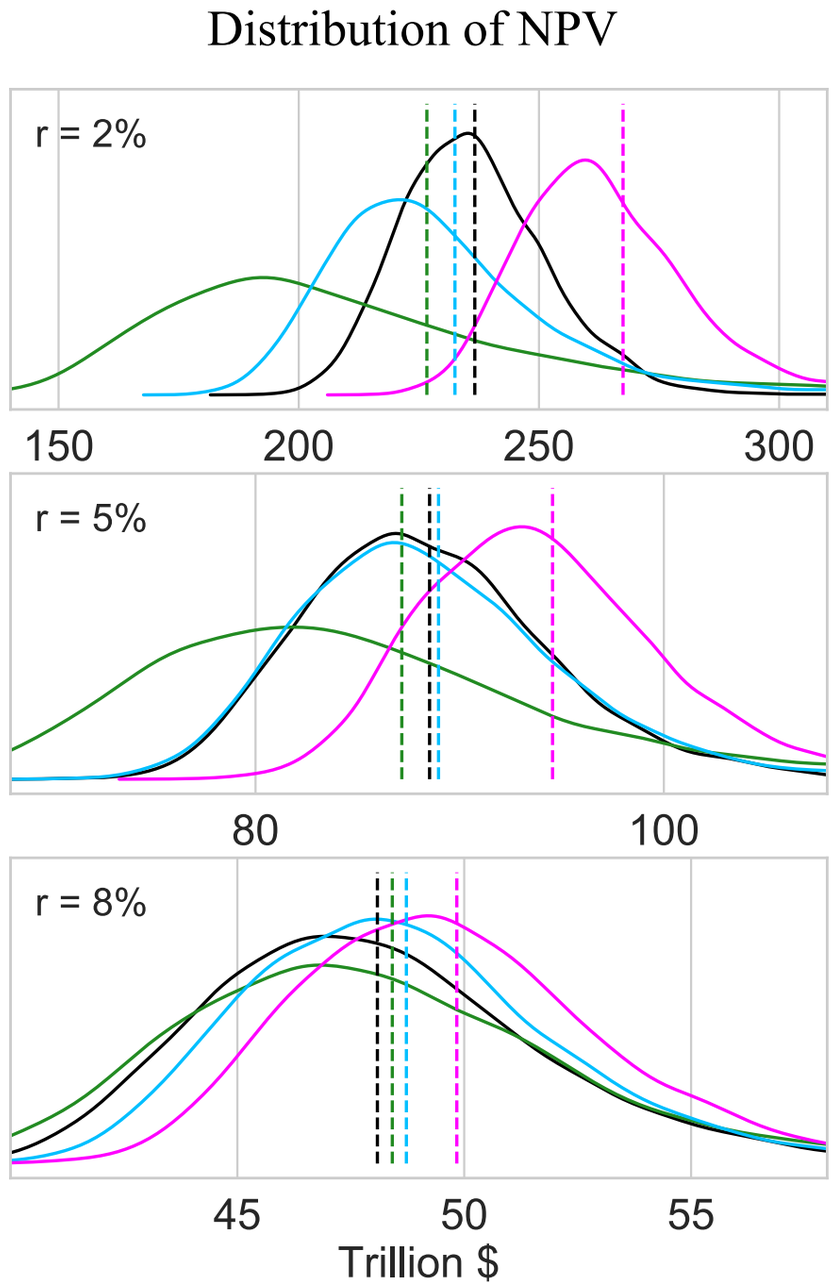


Components of the energy system

Scenarios for the green energy transition







Predicted cost of the green energy transition under different scenarios

Way, Mealy and Farmer, 2020.

Fast renewable green energy transition is cheaper than business as usual!

We need a better map of the economy

Hypothesis

- Our understanding of the economy and our ability to predict on many levels will become dramatically better when we are able to map out and simulate the production network at fine scale and link to financial markets
- Ultimately we want to link to other social models, e.g. to predict how an epidemic will affect supply chains

Complexity Economics is a young science

Key problems to be solved for ABM to be predictive time series models

- Parameter estimation (Platt)
- Initial condition estimation
- Data (data, data, data, …)

Economic Forecasting with an Agent-based Model

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Proof of principle – just a start

Global microeconomics

Let macro emerge from micro

Takes advantage of heterogeneity
Much more data at microscale
Better statistical significance
Endogenous dynamics
Can model emergence
Predicts more things

We are facing serious problems:

financial crises

inequality

climate change

Complexity economics offers new solutions