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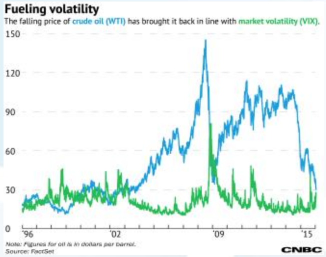
science for global insight

Modeling to support public policy planning in the VUCA world: Three examples

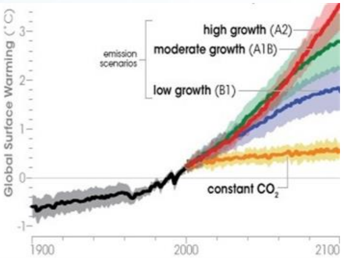
Elena Rovenskaya
rovenska@iiasa.ac.at
Program Director, Advancing Systems Analysis Program
International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Four major challenges to decision making of modern age

Volatility



Uncertainty



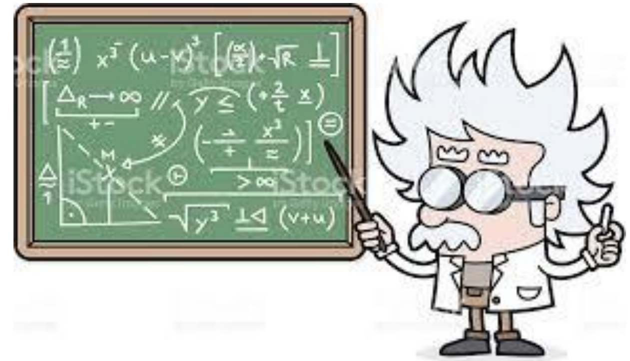
Complexity

Ambiguity

To be useful for informing public policy planning in the VUCA world, models should be

- **Agile**
- **Reliable**
- **Relevant**

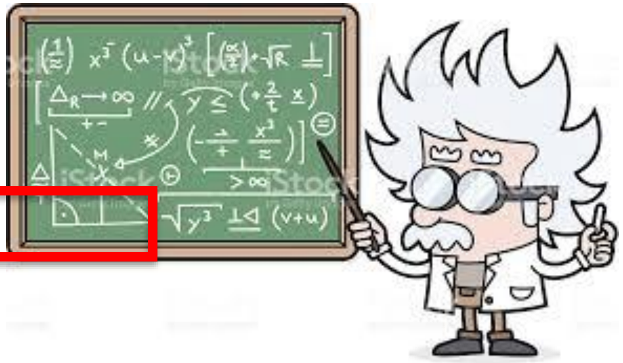
Fit-for-purpose modeling



0. Predict
1. Explain
2. Guide data collection
3. Illuminate core dynamics
4. Suggest dynamical analogies
5. Discover new questions
6. Promote a scientific habit of mind
7. Bound (bracket) outcomes to plausible ranges
8. Illuminate core uncertainties
9. Offer crisis options in near-real time
10. Demonstrate tradeoffs/suggest efficiencies
11. Challenge robustness of prevailing theory through perturbations
12. Expose prevailing wisdom as incompatible with available data
13. Train practitioners
14. Discipline the policy dialogue
15. Educate the general public
16. Reveal the apparently simple/complex to be complex (simple)

Epstein JM (2008): Why model? Journal of Artificial Societies and Social Simulation, 11(4): 12.

Fit-for-purpose modeling



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IIASA

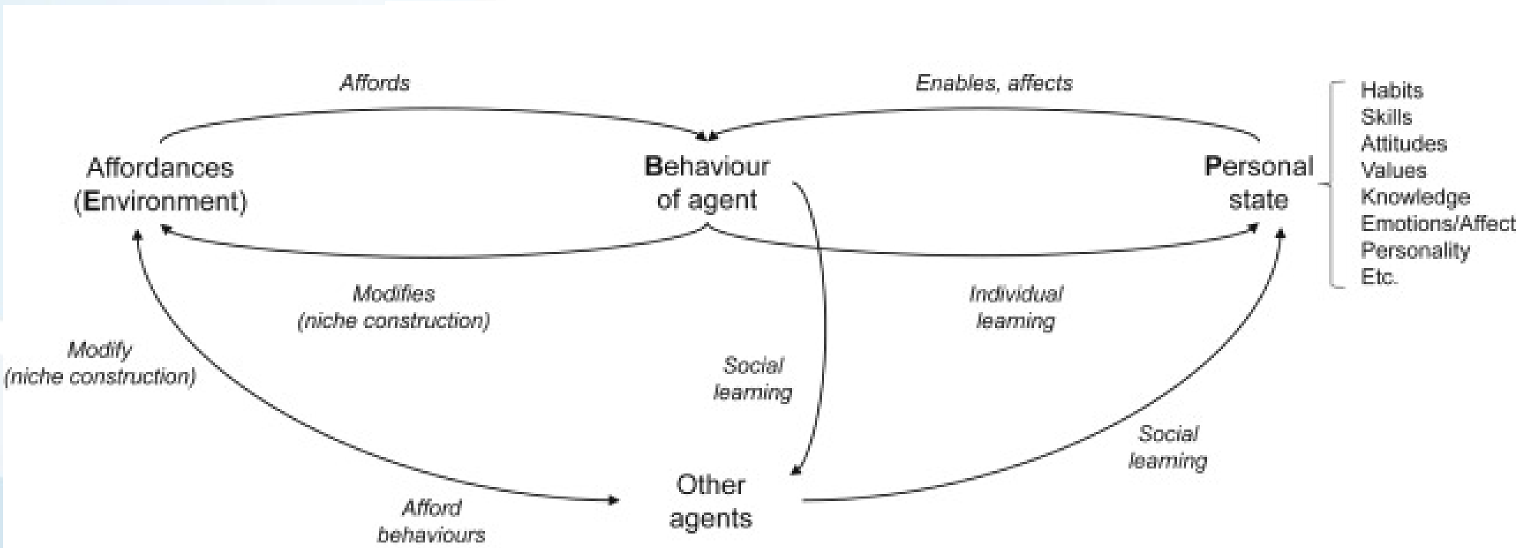
Three examples from IIASA research:

(1) Agent-based modeling of people’s behavior

(2) Stock-flow consistent models of economic incentives

(3) Risk-adjusted optimization for robust solutions

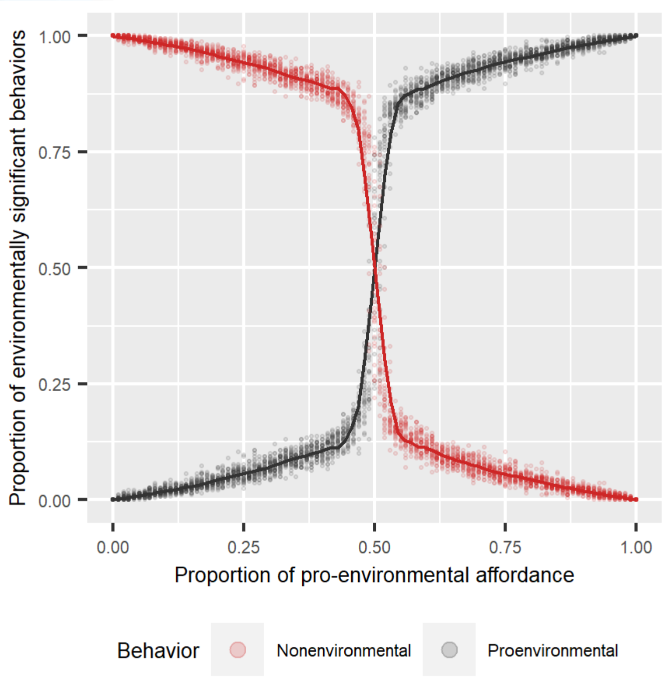
(1) Agent-based modeling (ABM) of people's behavior



- ABM: Dynamic interactions of agents-humans with each other and with the environment
- Decentralized decisions by individual agents
- Behaviors emerge as a function of affordances, social learning, and habits

RO Kaaronen & N Strelkovskii (2020): Cultural Evolution of Sustainable Behaviors: Pro-environmental Tipping Points in an Agent-Based Model, One Earth, 2(1): 85-97

(1) Agent-based modeling (ABM) of people's behavior



- In a stylized model setting, a "phase" transition from non-environmental to pro-environmental behavior is observed once the affordance level exceeds a certain threshold

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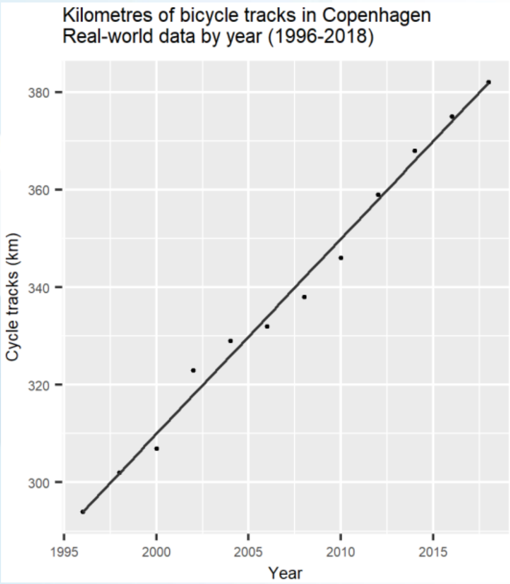
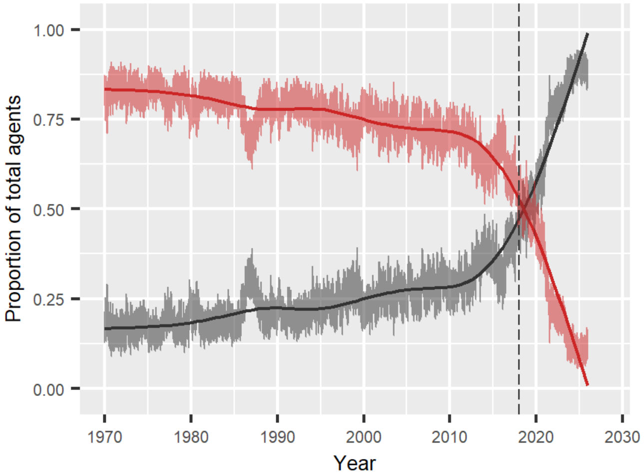
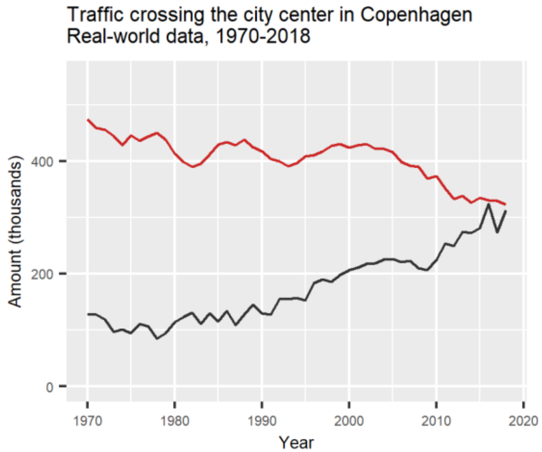




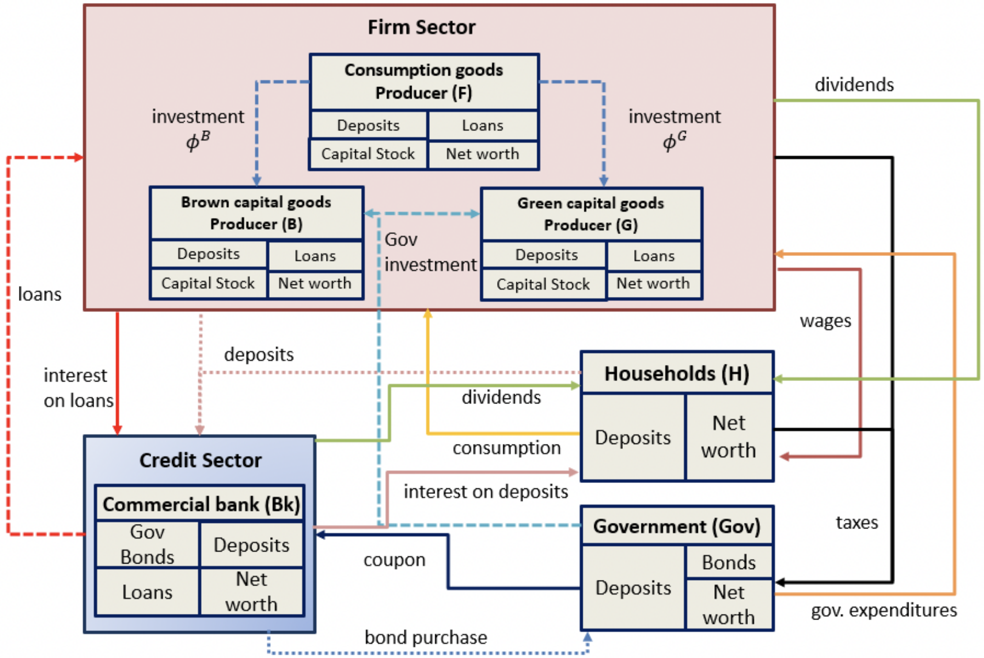
Model-based dynamics



Data

- In a model version simulating the development of biking in Copenhagen, rising affordances (capacity of bike paths) indeed led to a significant shift towards pro-environmental mobility choice (biking vs. driving a car)

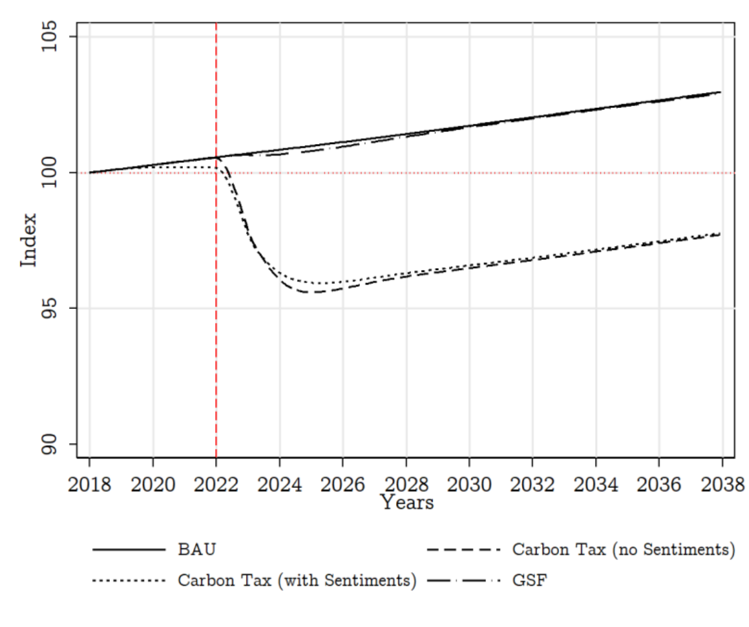
(2) Stock-Flow Consistent (SFC) models of economic incentives



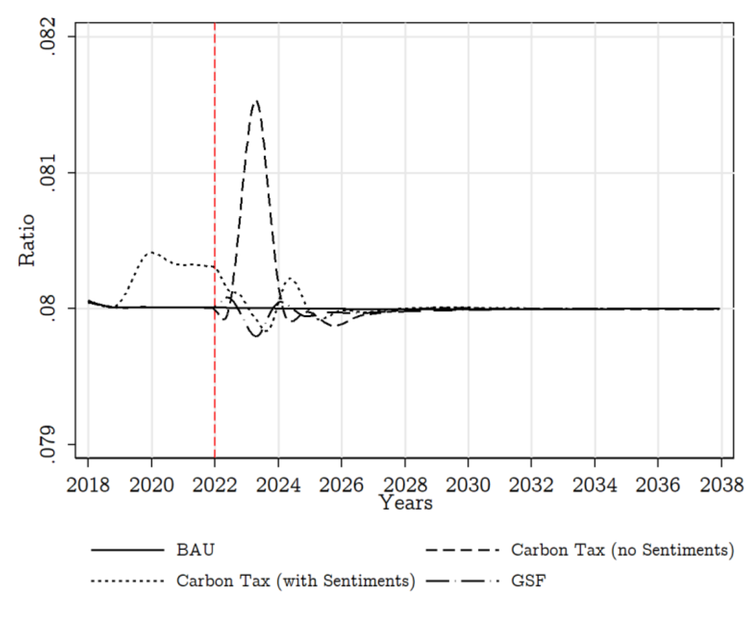
- STF models rely on data from balance sheets and transaction flow matrices and allow to simulate out-of-equilibrium dynamics of the economy under various policy interventions
- They aim to keep track of all financial flows using strict accounting identities which might also reveal potential unintended consequences from various sectors

N Dunz, A Naqvi, I Monasterolo (2018): Climate policies, transition risk, and financial stability. Journal of Financial Stability. *Forthcoming*

(2) Stock-flow consistent models of economic incentives



Real GDP



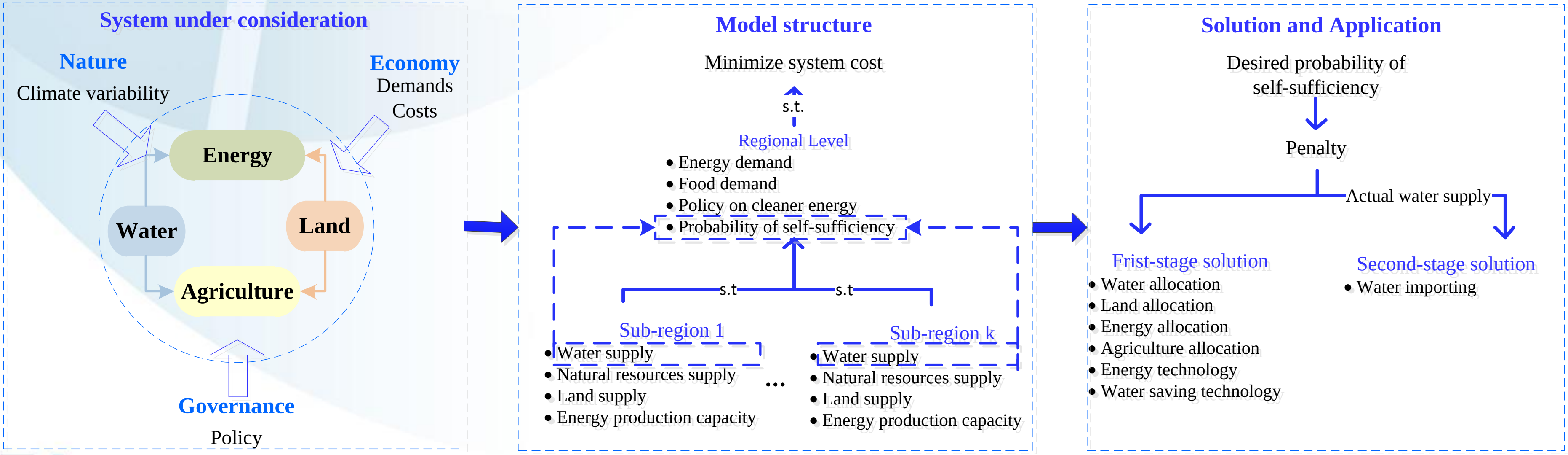
Capital Adequacy Ratio (CAR)

- Macroeconomic and financial effects of the introduction of a carbon tax can be simulated
- The results demonstrate that bank's anticipation, through stronger climate sentiments, of a climate aligned policy could smooth the risk for financial stability and foster green investments

(3) Risk-adjusted optimization for robust solutions

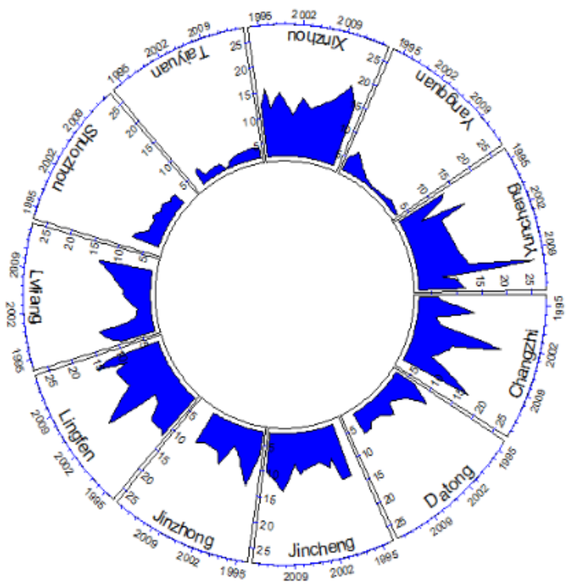
- Decision support tools are based on optimization of a certain objective (costs, profits, …). An optimal solution can be sensitive to input parameters which are uncertain in the future.
- Risk-adjusted optimization is carried out under "chance" constraints, i.e., we require that constraints hold with a certain probability. In this way, we obtain "robust" solutions.

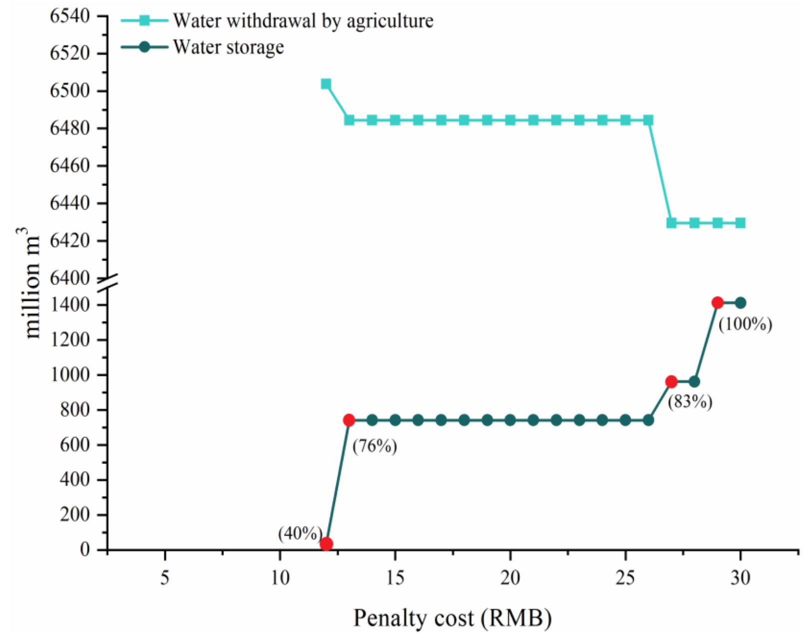
Food-water-energy nexus model:



(3) Risk-adjusted optimization for robust solutions

Case study: Shanxi province, China with large coal mining and scarce water





Input data: Water availability in Shanxi varies across prefectures and time

Model-based recommendation: Different food- and energy security levels require deployment of different water-saving solutions

J Gao et al. (2020): Strategic Decision-Support Modeling for Robust Management of the Food–Energy–Water Nexus under Uncertainty. Journal of Cleaner Production. *In review.*

General remarks

- ABMs is a suitable tool for modeling behavior and emergent phenomena, but it is costly and validation is challenging
- Intermediate-complexity models such as SFC models can be instrumental to explore a new phenomenon
- Risk-adjusted optimization enables the derivation of solution options that are insensitive to input uncertainties
- A suite of models of different complexity and type should be used to provide robust policy advice

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Questions? Thank you for your attention.