

Innovating in Systems: Select Crowds & Many Models

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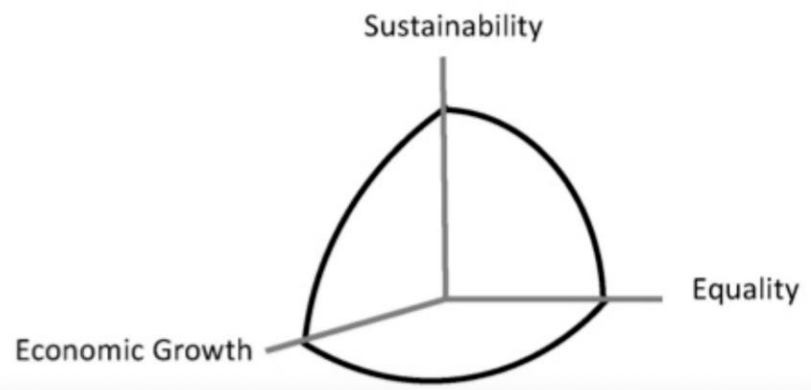
Santa Fe Institute

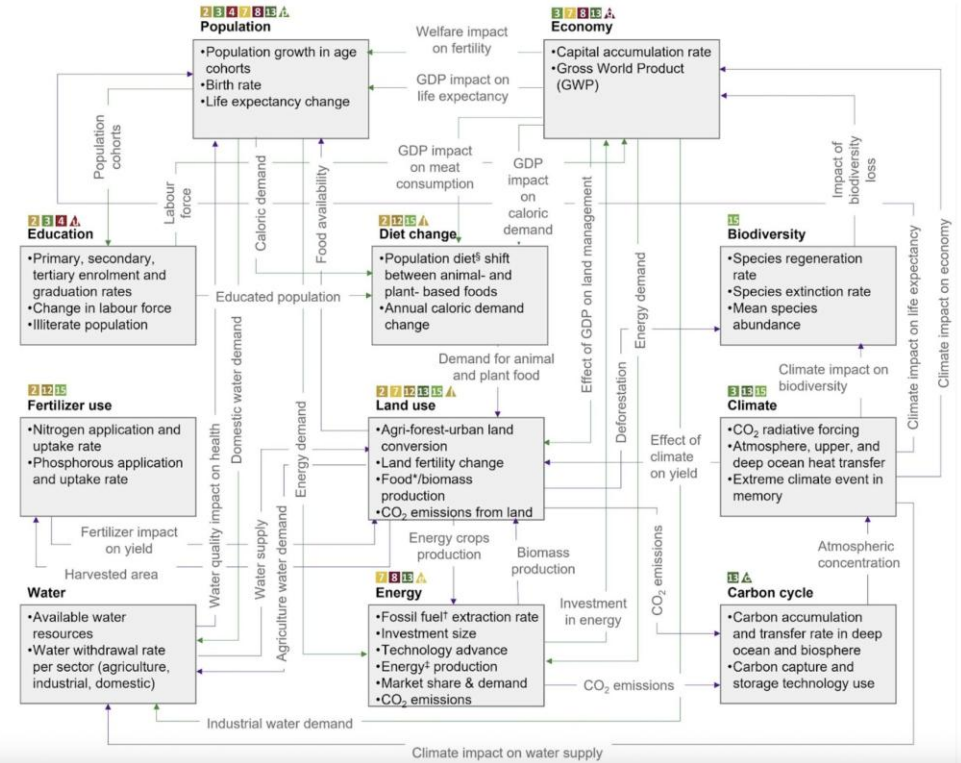
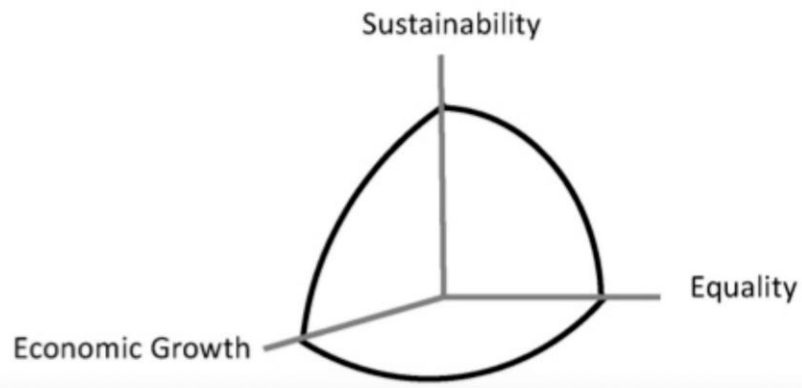
Goal

Innovate within **complex system of systems** – economic, ecological, political, and social.

Challenges:

- Understanding complexity
- Policy alignment & coordination
- Transitions

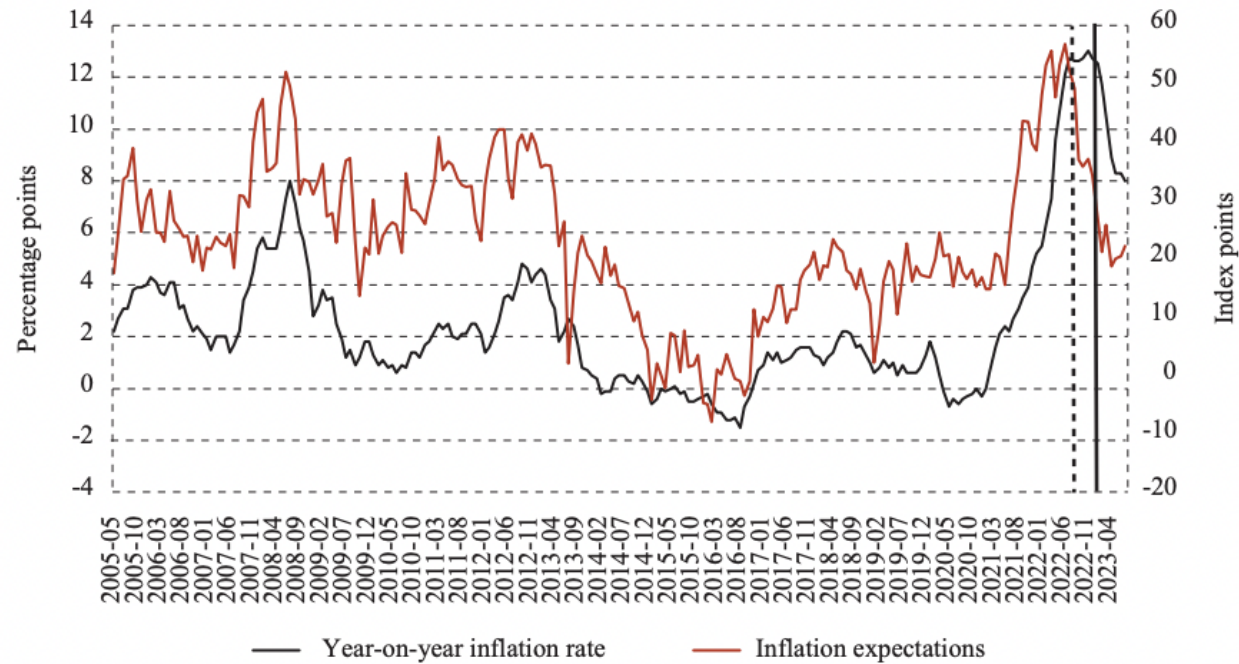




Complexity

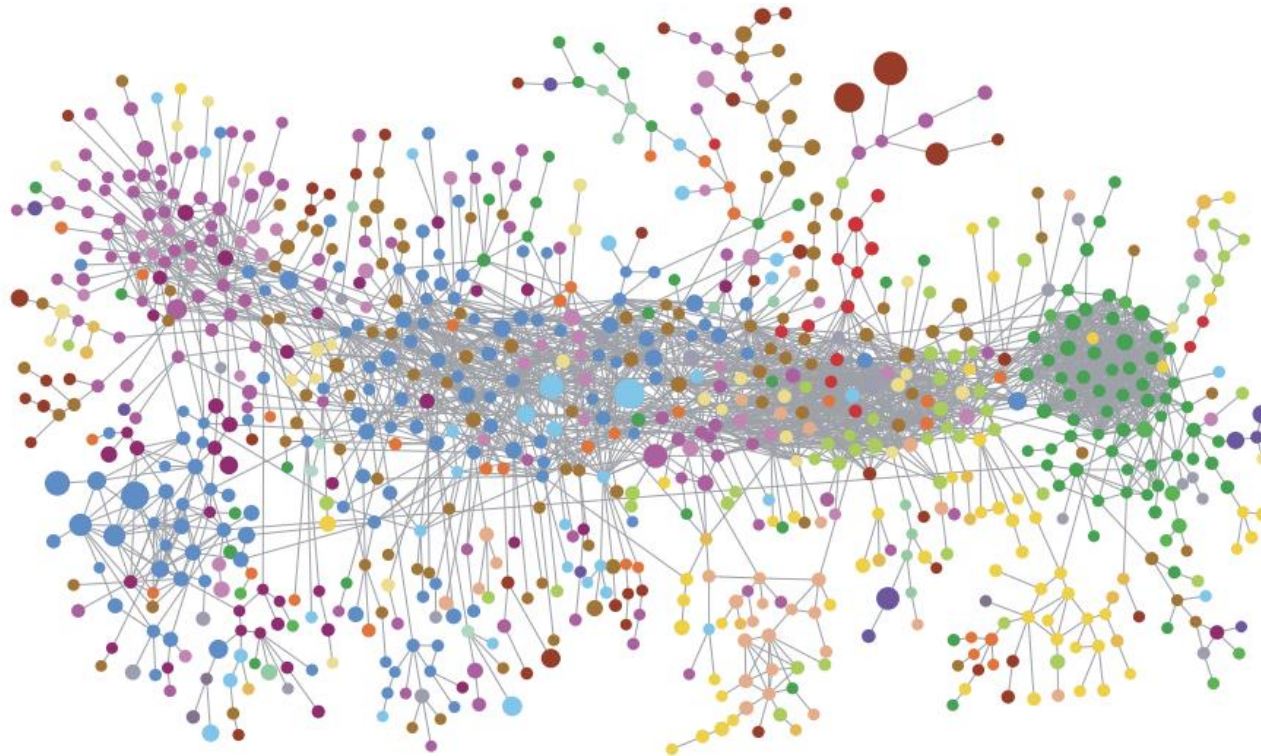
BOAR: between ordered and random

HICP inflation (year-on-year) rates and inflation expectations in Croatia



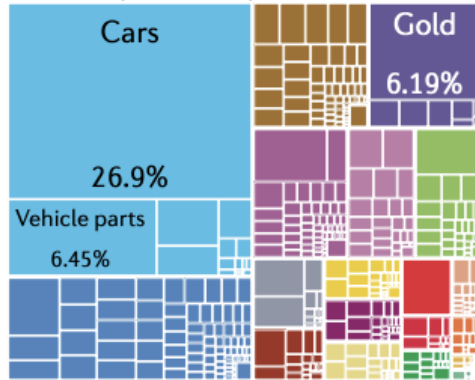
Complexity

DEEEP: difficult to evolve, engineer, explain, predict

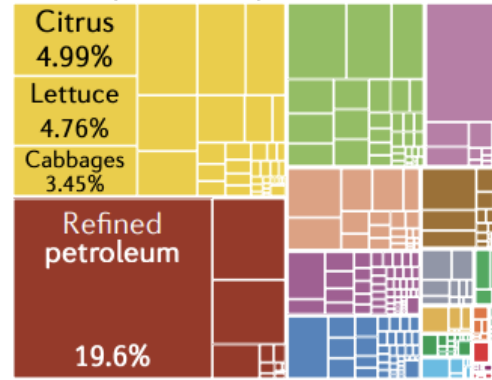


Carving Nature at its Joints

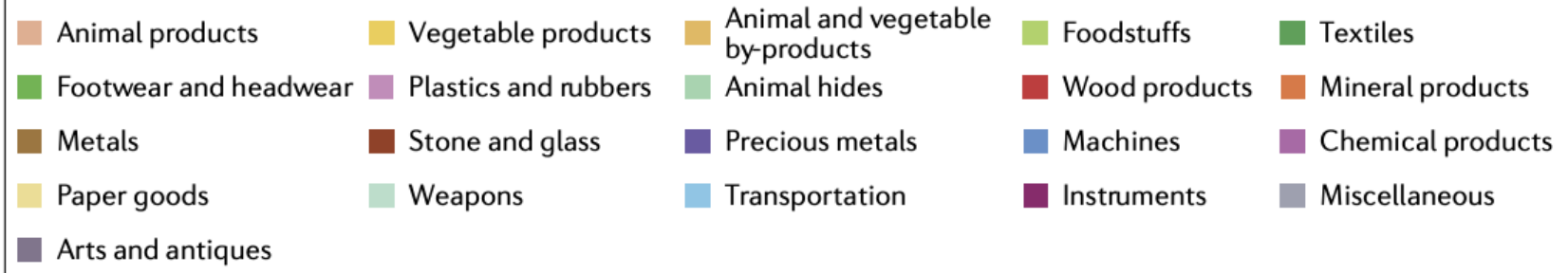
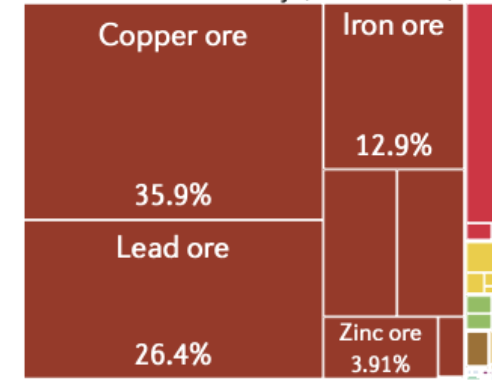
Ontario (ECI = 0.15)



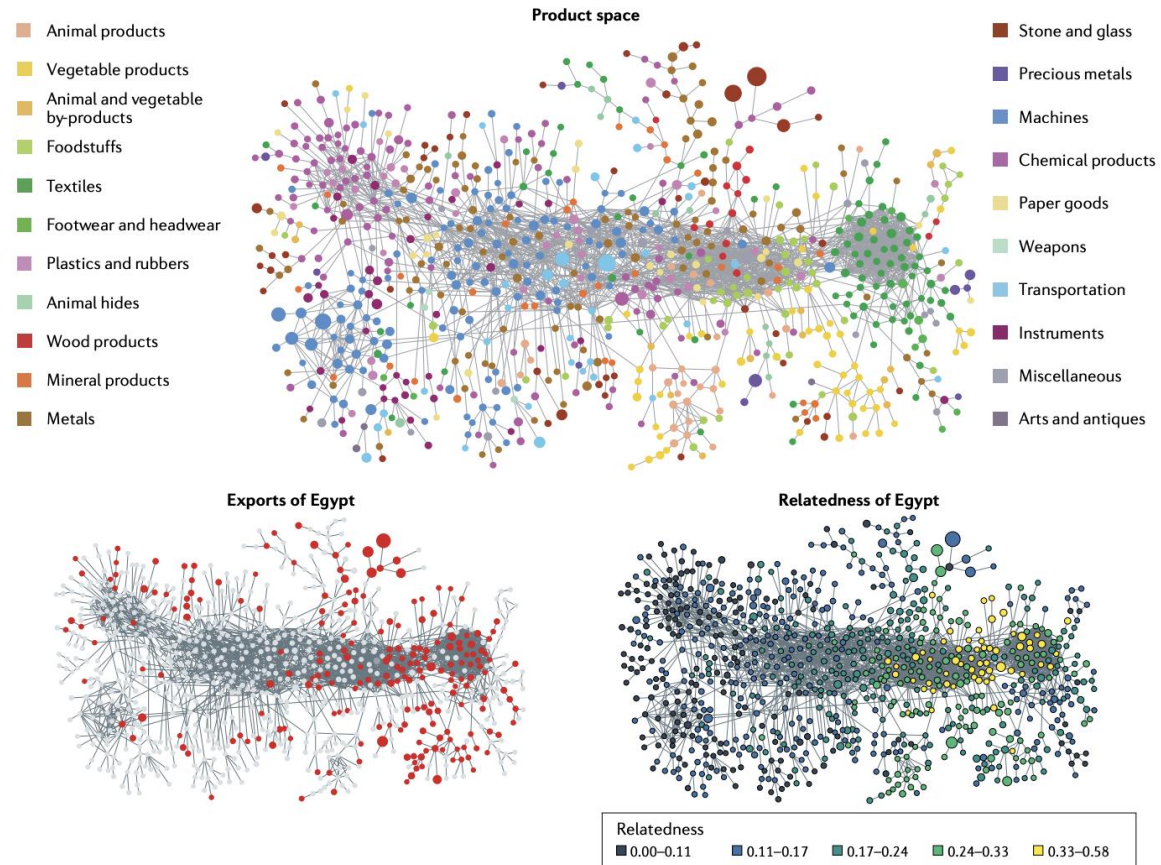
Murcia (ECI = -0.48)



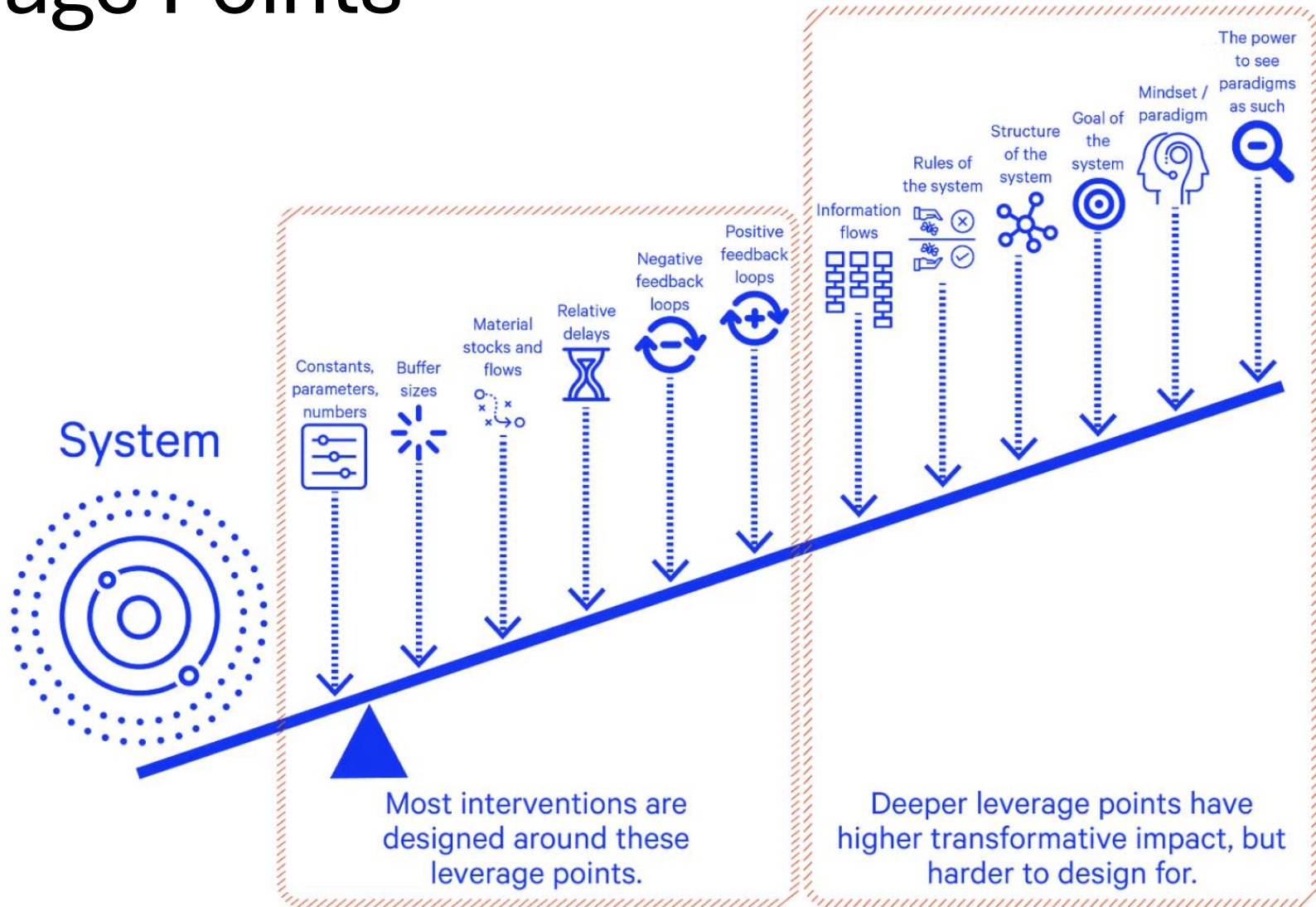
Trans-Baikal territory (ECI = -1.02)



Nexus of Understandings



Leverage Points



Categories of Interventions

#1 Rates/Flows/Capacities: Normal Policy

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#2 Information/Feedbacks: Balancing & Reinforcing

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#3 Institutions: Rules of the Game

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#1 Rates/Flows/Capacities: Normal Policy

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#3 Institutions: Rules of the Game

#4 Goals/Paradigms: Big Why

Which Levers Do We Pull?



Multi-Dimensional Output

(Growth, Equality, Environment, Health, Climate)

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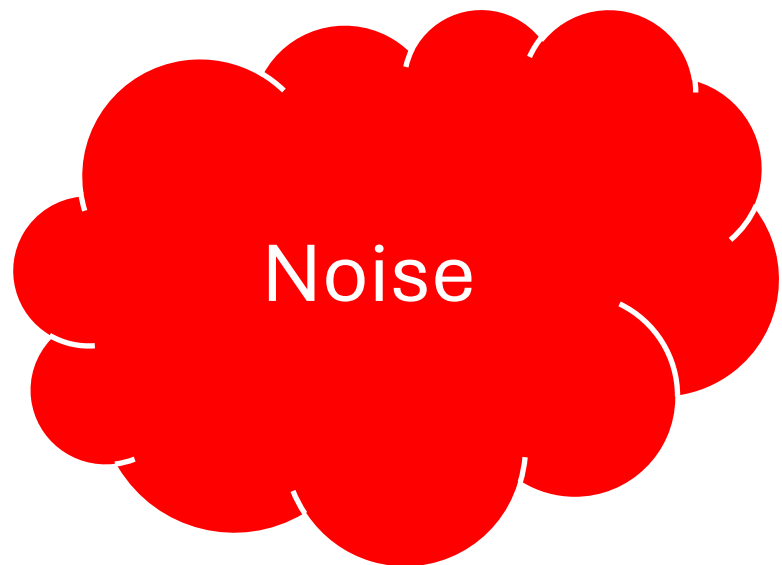
Three Classes of Predictions: Up, Down, No Effect

$$3^5 = 243$$

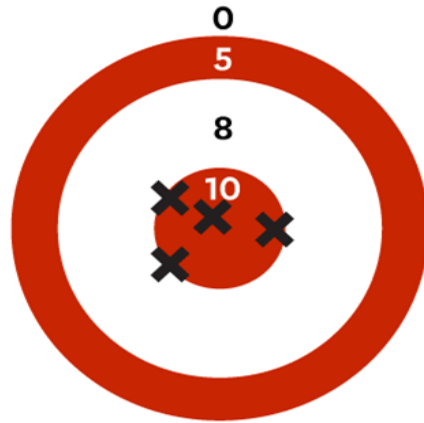
Four Models

Growth:	Up	Up	Up	NE
Equality:	Up	Dn	Dn	Dn
Environment:	Dn	NE	NE	NE
Health:	Up	Up	NE	Up
Climate:	Up	Up	Up	Up

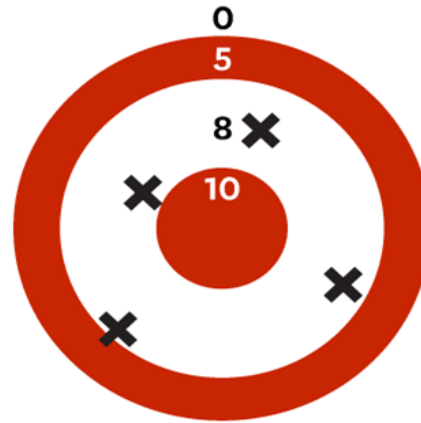
Disentangling



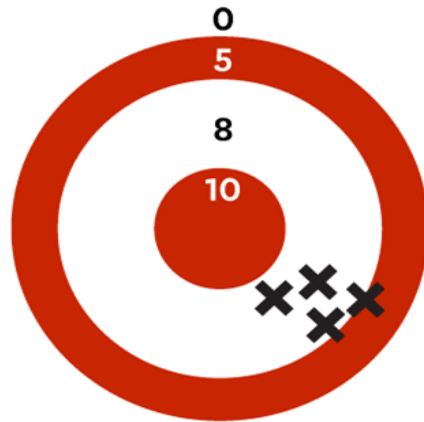
Noise & Bias



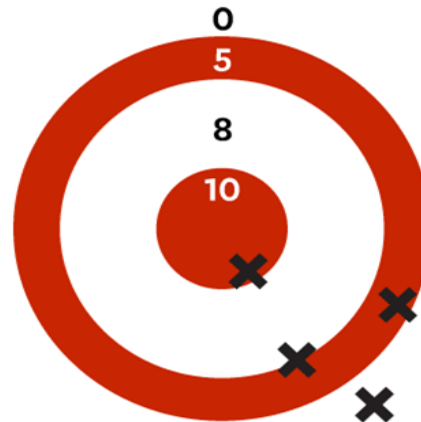
A. Accurate



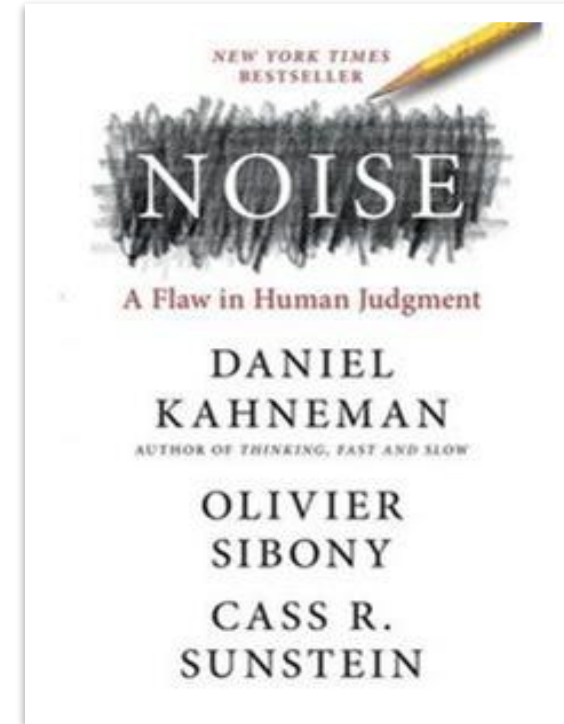
B. Noisy



C. Biased



D. Noisy and biased



Many Models

Many Noisy Models: Noise

Many Biased Models: Meaning of Bias

Many Diverse Models:??

Why Many Models Prediction

Diversity Prediction Theorem

Error = Average Error - Diversity

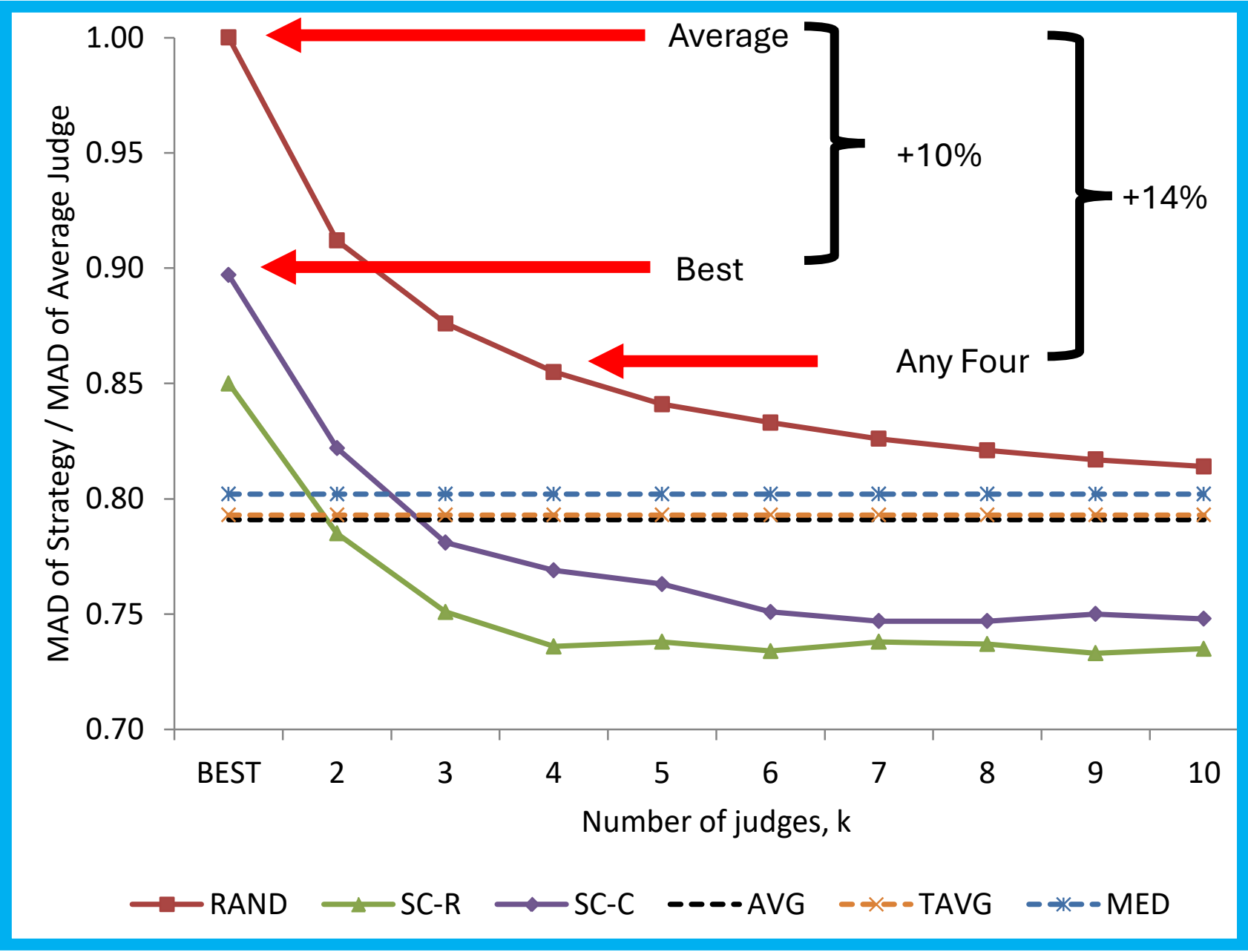
$$(c - q)^2 = \frac{1}{n} \sum_{i=1}^n (s_i - q)^2 - \frac{1}{n} \sum_{i=1}^n (s_i - c)^2$$

Economic Forecasts

28,000 forecasts by professional economists

6 economic indicators

Crowd mean 21% better than average economist



Four Models

	<u>#1</u>	<u>#2</u>	<u>#3</u>	<u>#4</u>
Growth:	Up	Dn	Up	NE
Equality:	Dn	Dn	Up	Dn
Environment:	Dn	NE	NE	NE
Health:	Up	Up	NE	Dn
Climate:	Up	Up	Up	NE

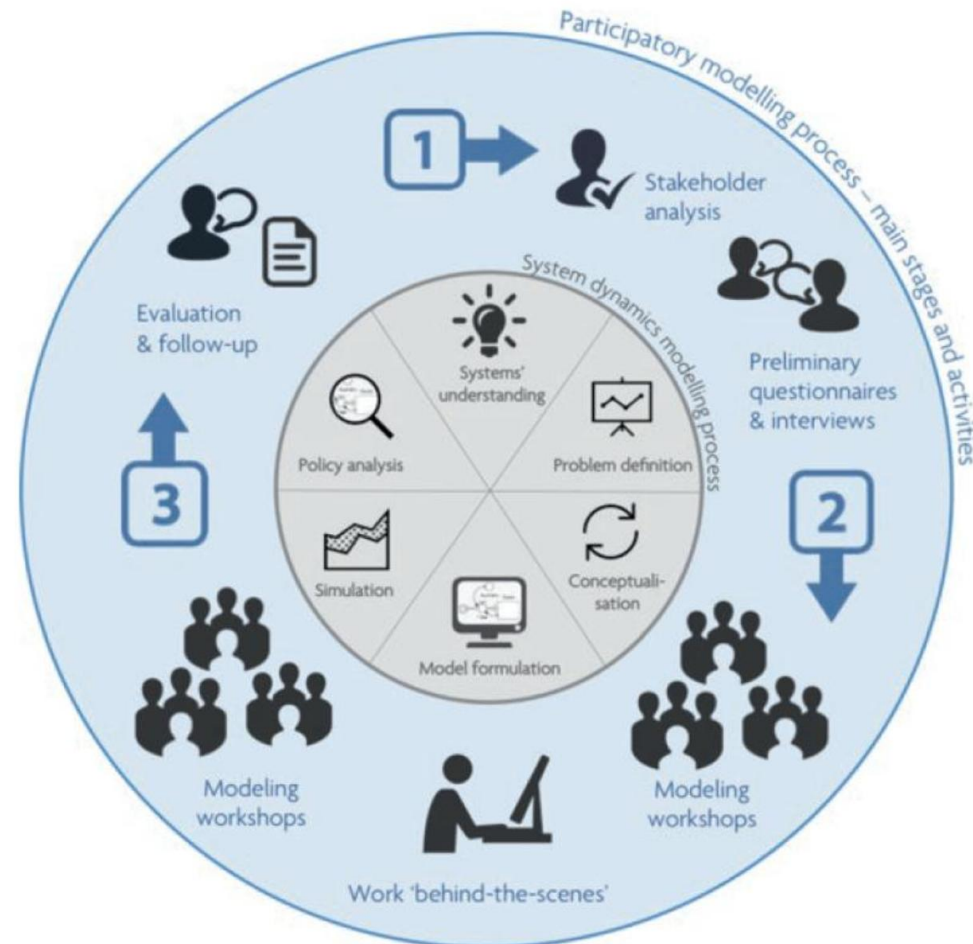
Participatory System Dynamics Modelling (PSDM)

Participatory system dynamics modeling involves stakeholders in the conceptualisation, specification, and synthesis of knowledge and experience into a model

Generates context-specific **Causal Loop Diagrams (CLDs)**. CLD synthesis can provide a stakeholder-derived '*Theory of Change*'

Provides *complementary evidence* & an *ideation space* for future **policy scenarios**

Progressively shapes/*changes mental models*, helps *build capacities* for **system innovation**



Source: Videira, N., Antunes, P., Santos, R. (2017). Engaging Stakeholders in Environmental and Sustainability Decisions with Participatory System Dynamics Modeling. In: Gray, S., Paolisso, M., Jordan, R., Gray, S. (eds) Environmental Modeling with Stakeholders. Springer, Cham. https://doi.org/10.1007/978-3-319-25053-3_12



Why Many Models?

Any one model will be wrong (often)

You can disentangle noise, bias, and diversity

Models can learn & calibrate

Policy makers learn

Better Policies