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Infrastructure, Growth and Sustainable Living

ITRC conference: The future of national infrastructure systems & economic prosperity
St Catharine’s College, Cambridge

Liz Varga
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Transforming knowledge into action

Overview

- Infrastructure investment and economic growth
- Sustainable living
- Method in design
- ICIF and EU-Innovate acknowledgements

Overview

- Using traditional approaches
  - investment in infrastructure and resultant economic growth (change in GDP) is generally positively correlated
  - real effects are disputed, see for example Munnell (1992), and a post 1970s slowdown is evident.
- A complex systems perspective
  - highlights inter-dependencies and co-evolutionary effects,
  - questions the simplistic relationship between infrastructure and economic growth

Energy, transport, water, waste and telecoms

Schools, hospitals, fire and police stations

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What about museums, parks, libraries?

Infrastructure assets

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- Not the same as other types of capital stock (Égert et al, 2009)
  - natural monopoly characterised by public good
    - citizens gain universal access to basic requirements
    - address poor service and ecological concerns via public forums and political means
  - network effects and spill-overs into other sectors
    - property prices hikes when OFSTED changes a school evaluation.
  - large with long life-cycles of investment and alternative financing models
  - extensive government intervention
    - various forms of regulation or state ownership which can have competition enhancing effects
  - economies of scale due to network externalities by connecting both regions and countries.
  - purpose of infrastructure enables economic activity, as well as social cohesion

8 issues in juxtaposing investment and growth

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- **First** is that growth varies with the type of infrastructure into which investment is made.
  - investment in transportation infrastructure exhibits different economic growth from non-transportation (energy and telecoms).
  - with transport infrastructure, growth resulting from investment is higher for roads compared to other modes of transport (Melo et al, 2013).

Road investment

2. Spatial and national differences

- Growth is not spatially consistent: different geographical configurations produce different rates of growth
- Average results for infrastructure growth disguises large differences between countries (Canning and Pedroni, 1999).

3. Operational efficiency

- Operational efficiency can be important for economic growth than additional new investment
  - improve the longevity of infrastructure investment, such as quality of build, charging for use, and taxation options.
  - additional investment may also disrupt operations and short-run economic growth.

4. Interdependency within a portfolio

- The condition of the nation's portfolio of infrastructure stock will determine investment priorities
  - Greatest economic growth may come from surprising investments, e.g. investment in health care may lead to a larger work-force capacity.

5. Disruptive technologies

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- Technology capability does not arise incremental.
- Disruptive technologies have enabled smaller scale infrastructure components, which are significantly more efficient.
- Investment in current technologies is a risk which can be undermined by a new wave of technological growth, and if the state does not own this risk, then it will need to incentivize business to own it.

6. State vs private ownership & taxation

- Ownership and taxation regimes influence investment
- PFI encouraged investment in social infrastructure (e.g. schools, prisons).
- Paralysis of investment by over-analysis and legislation can lead to significant delays to decision making which stifle private and state investment.

7. Investment and growth are non-linear

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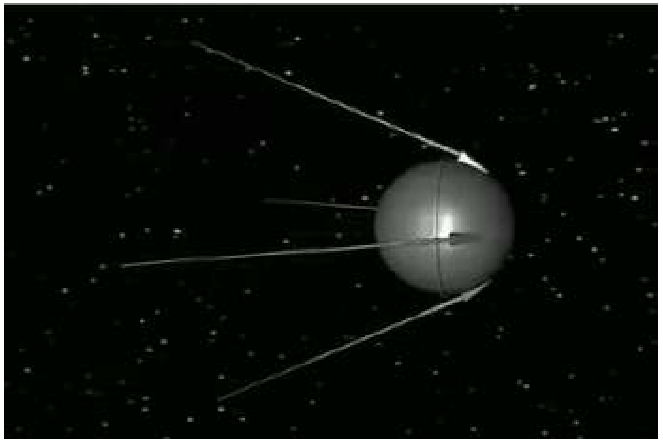

- Telecoms, infrastructure investment appears to reach a critical mass when it is a near universal service, after which there is significant positive link between investment and economic growth

8. Dynamics of investment and use

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- Dynamics emerge from the patterns of infrastructure investment and growth
- Built infrastructure attracts industry and business which then attracts further investment
- Planning for sufficient infrastructure to meet unknown and contingent demand is a dynamical problem exacerbated by long timescales for infrastructure development

Sustainable futures

- Compound these issues with the inevitability of pro-active sustainable behaviours (sustainable lifestyles 2.0), and a new set of opportunities emerge.

4 normative sustainable lifestyles

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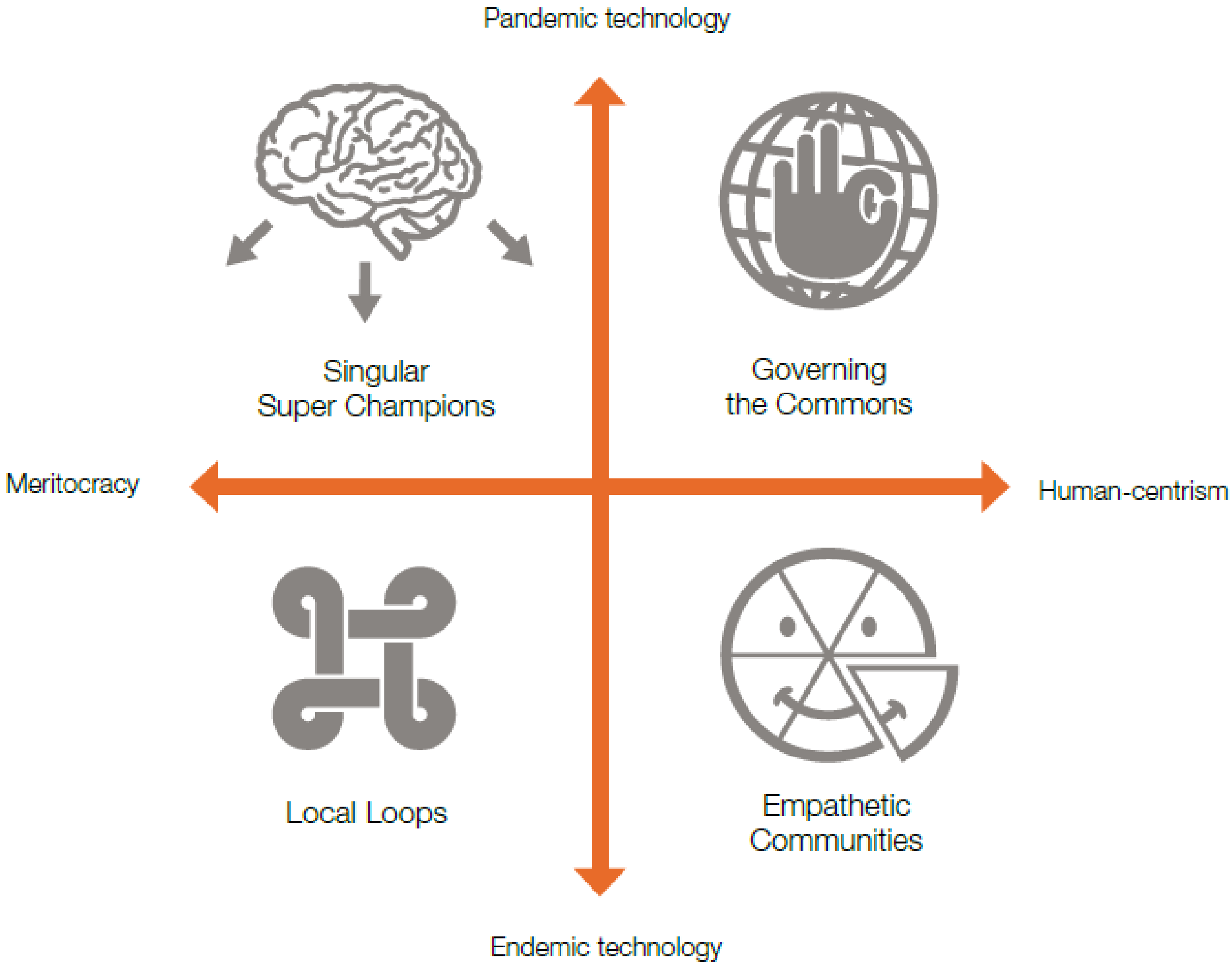

In the SPREAD project we have defined the material footprint of a sustainable lifestyle at 8000 kg per annum (p.a.) for one person

http://www.sustainable-lifestyles.eu/fileadmin/images/content/D4.1_FourFutureScenarios.pdf p11

Unsustainable Lifestyles

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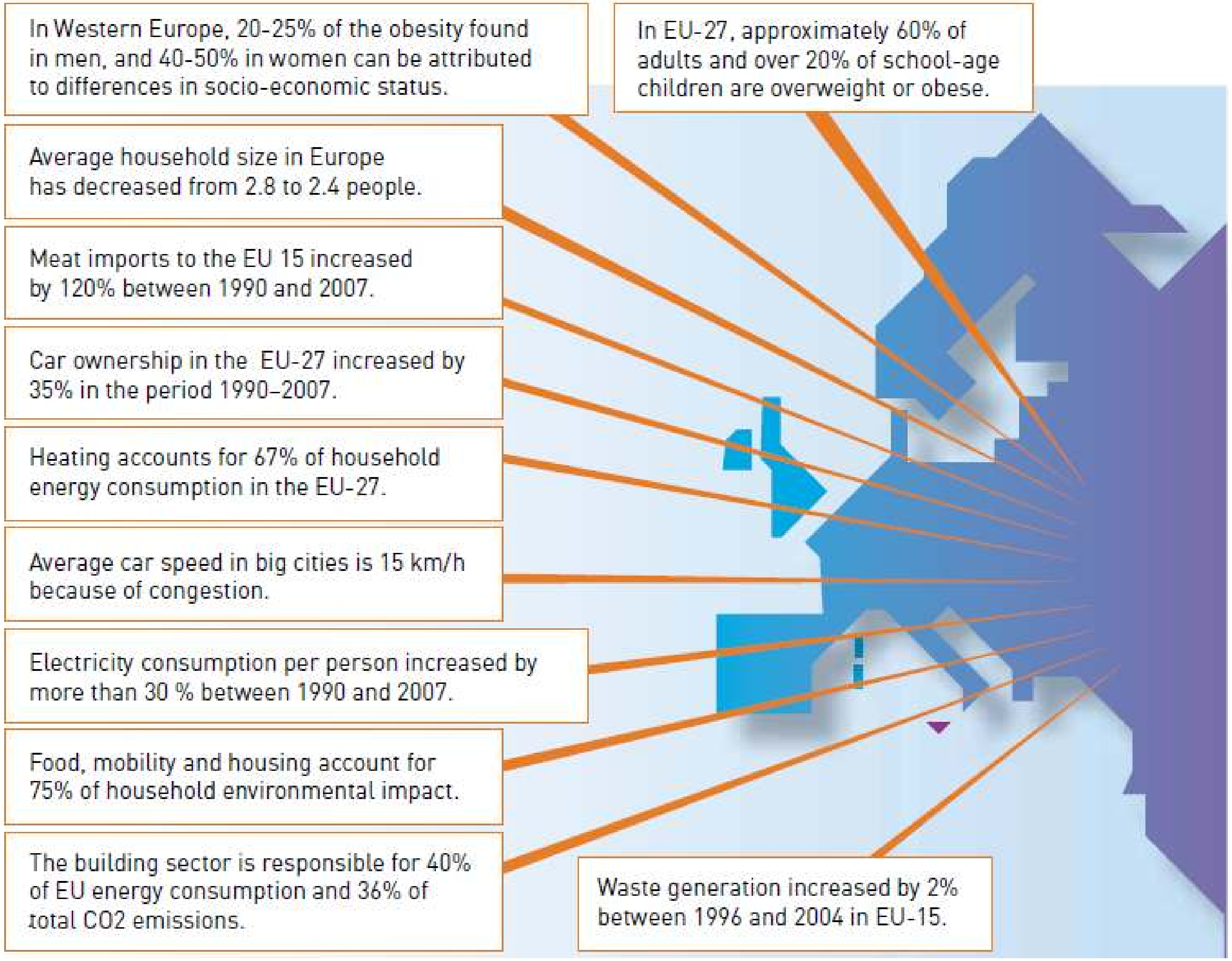

http://www.sustainable-lifestyles.eu/fileadmin/images/content/D1.1_Baseline_Report_short.pdf p7

a. Sustainable demand

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- Lower demand patterns will emerge: local renewable options will be adopted to reduce carbon footprints to sustainable levels.
- 9 billion citizens live sustainably by 2050:
  - SPREAD 2050 scenarios (2012) for sustainable lifestyles in Europe
  - "Vision 2050" and "Changing Pace" reports from the World Business Council for Sustainable Development (2010, 2012).
- A reduction in overall resource use through active roles of users in advancing sustainability is perceived as a critical activity to reducing demand.

b. Localization and urbanization

- Population will gravitate to urban dwellings.
  - Urbanization and population density effect economies of scale (Esfahani, Ramirez 2003).
- Local resources will be key contextual drivers for infrastructure demand.
- Effects on economic growth of investment will change:
  - For telecoms, concentration of population is better
  - For transportation concentration can lead to congestion and reductions in growth.

c. Sustainable user innovation and entrepreneurship

- The economy will grow through sustainable user innovation:
  - user practices to live sustainable lifestyles will be developed by businesses for diffusion.
- Sustainable modes of entrepreneurship are already replacing conventional modes
  - focus on reducing environmental impacts and increase quality of life,
  - not forgetting the economic focus of conventional modes which are needed to compete in markets (Schaltegger and Wagner, 2011).

d. Exploitation of services interdependencies

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- Infrastructure services will become more efficient through exploiting interdependencies at all scales
  - avoiding waste
  - reducing CO2 omissions
- Over the last 50 years, infrastructure has shifted from unconnected independent systems to interconnected national networks (CST, 2009).
- Leveraging interdependencies is a key challenge for next generation infrastructure in particular the use of technology and information to reduce uncertainty and diminish avoidable consumption.

Purpose of ABM

- Modeling the agent based practices of investment decisions, together with user innovations, intends to
  - shows the coevolution of lifestyles and infrastructure diversity,
  - demonstrating consequences for
    - economic growth,
    - lower CO_2 emissions
    - new social norms

Multi-level perspective

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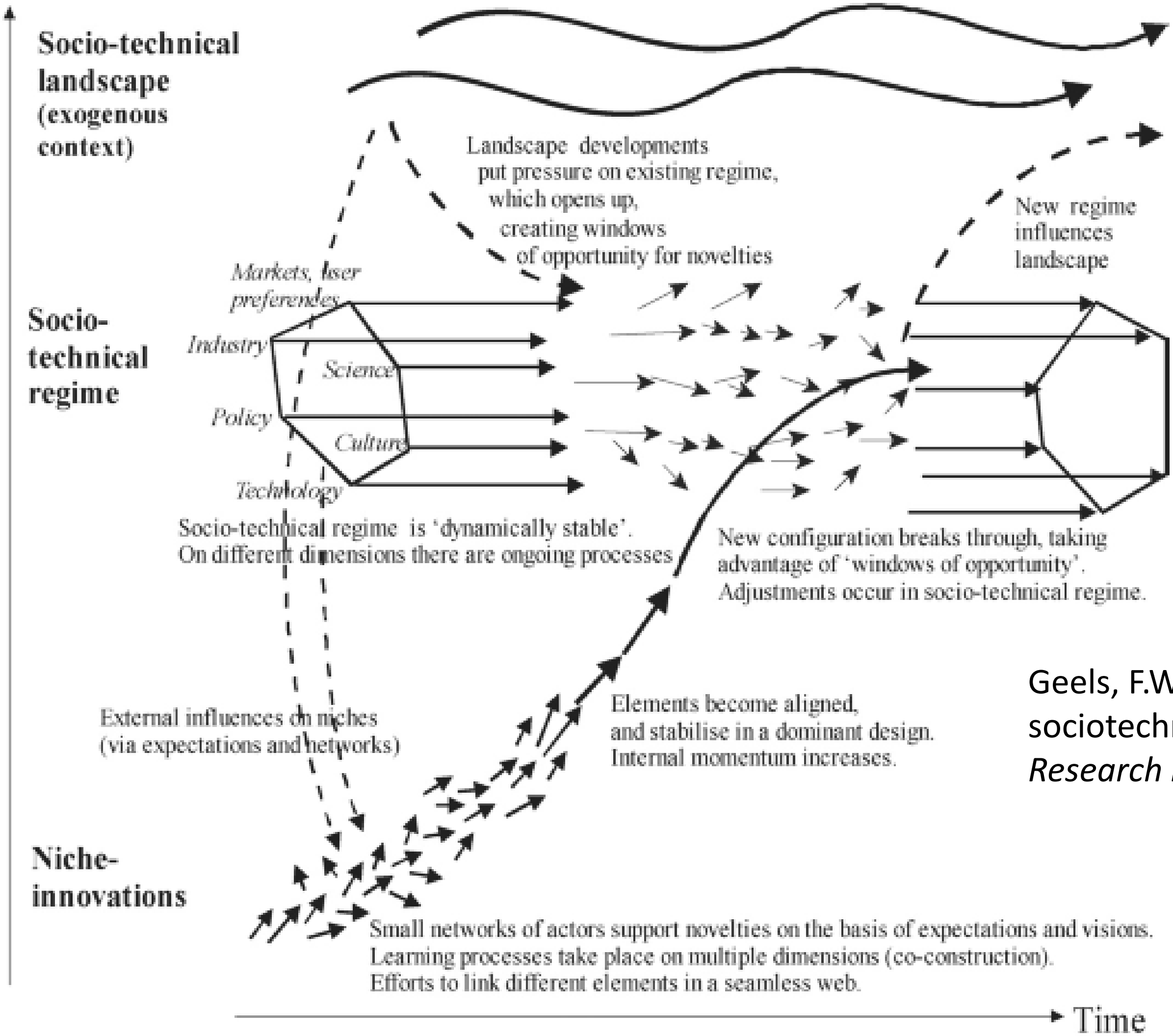

Geels, F.W., Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy,* 36, pp 399–417

MLP – SPREAD scenarios

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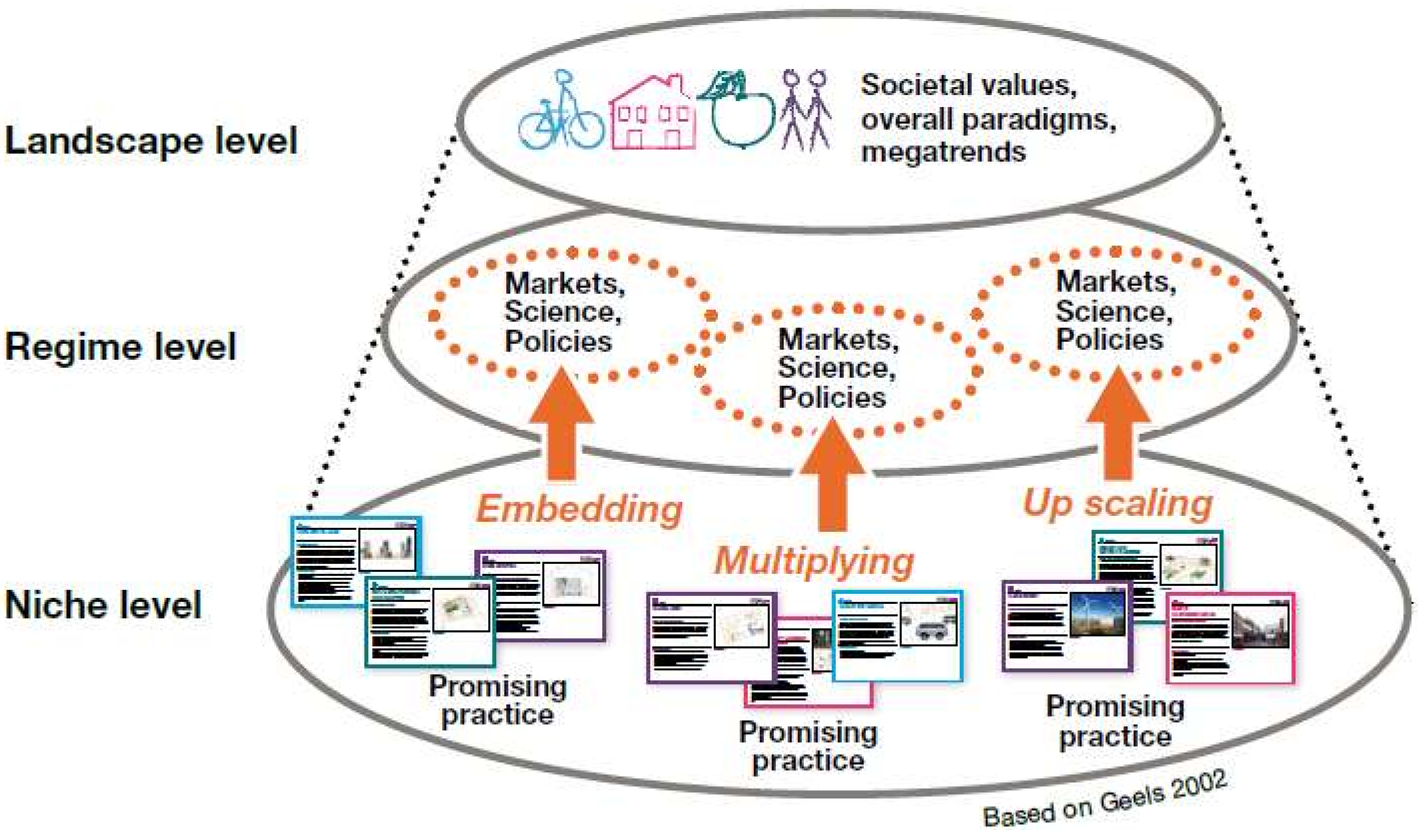
How to spread sustainable lifestyles?



http://www.sustainable-lifestyles.eu/fileadmin/images/content/D4.1_FourFutureScenarios.pdf p3

The blue print for an ABM

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1 Type of research → **Theory development**
2 Research approach
3 Goal of research
4 Simulation technique
5 Simulation Environment
6 Phenomena to be explained
7 Purpose of simulation
8 Methodology
9 Experimental design
10 Simulation rationale
11 Model outline
12 World
13 Agents →
14 Mechanisms
15 Assumptions
16 Verification
17 Initial conditions
18 Boundary conditions
19 Time discretization
20 Fluctuations treatment
21 Visualization
22 Performance and scalability
23 Reproducibility
24 Robustness checks
25 Statistical ensembles
26 Statistical Analysis
27 Sensitivity analysis
28 Results validation →
29 Validation data sources
30 Known limitations
31 Outcome appraisal

1. Phenomena-level agents representing the operational behaviour of the system.
2. Macro-level agents representing landscape states of the system.
3. Meso-level agents representing regimes (ref: MLP)
4. Micro-level agents representing system participation by users.

A quantitative description of the results of simulations will be empirically validated against historical data, with further qualitative validation of visual phenomena generated by theoretical triangulation.

Helbing, D. (2012) 'Social Self-Organization: Agent-based simulations and experiments to study emergent social behavior', Springer.

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Thank you

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