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# What is Agent-Based Social Simulation?

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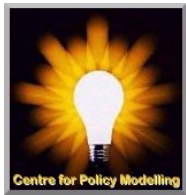
# Introduction



# An Example: Social Norms

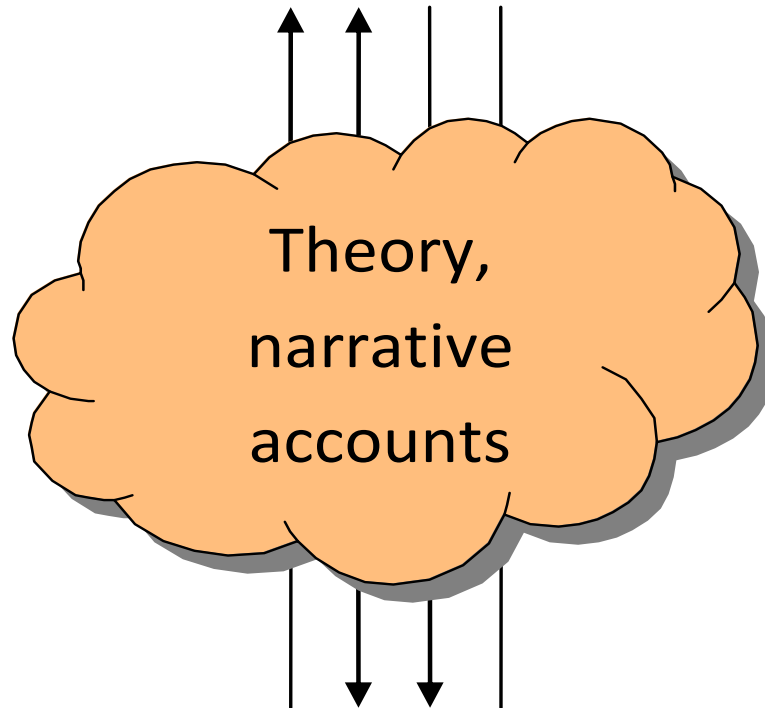
- A social norm emerges partly as a result of the beliefs, self-identity, actions, etc. of individuals
- But, *simultaneously*, the same norm constrains/influences the perceptions, beliefs, self-identity, actions, etc. of those individuals
- What we identify and label as a “social norm” is a dynamic *complex* of upwards “*emergence*” and downwards “*immergence*”
- Like many social phenomena, it has a complex micro-macro relationship/interaction at its core
- *Agent-based simulation allows the representation and exploration of such micro-macro complexes*

# Micro-Macro Relationships



**Macro/  
Social data**

Social, economic surveys; Census



**Micro/  
Individual data**

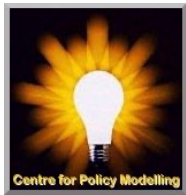
Qualitative, behavioural, social psychological data



# Some Key Historical Figures

- **Herbert Simon**
  - Observed administrative behaviour and described it using algorithms – ‘*procedural rationality*’ (rather than optimisation of utility)
  - Also (with Alan Newell) produced first computational models of aspects of cognition
- **Thomas Schelling**
  - A simple but effective example of individual-based modelling (in the coming slides)
- **Mark Granovetter**
  - Distinguished the importance of tracing individual interactions, ‘*social embeddedness*’
  - Highlighted such processes and structure (‘ties’)

# Origins of ABSS



## **(Occasionally) Interacting Streams:**

- Sociology, including social network analysis
- Distributed Computer Science Programming Languages
- Artificial Intelligence & Machine Learning
- Ecological Modelling

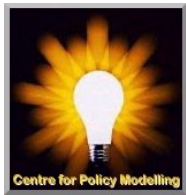
## **(Strangely) *Not much from:***

- (Mainstream) Economics
- Cognitive Modelling
- Numerical Simulation
- System Dynamics



# About Agent-Based Simulation

# *Analytic* **models**



*Where the model is expressed in terms that allow for formal inferences about its general properties to be made*

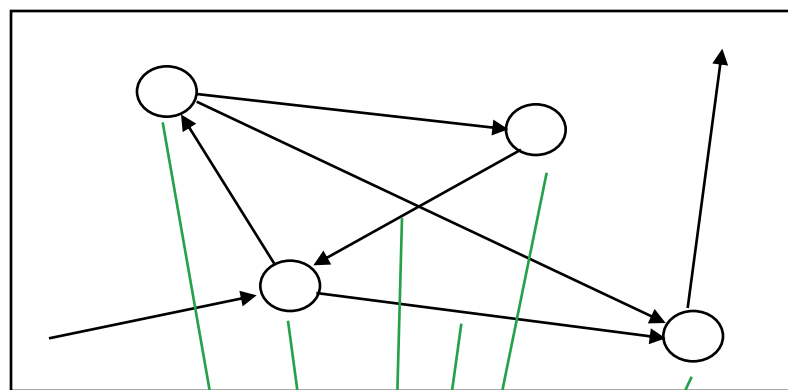
- e.g. Mathematical formulae
- Where you don't have to compute the consequences but can *derive* them logically
- Usually requires numerical representation of what is observed (but not always)

*Only fairly “simple” mathematical models can be treated analytically – the rest have to be simulated/calculated*

# Equation-based/statistical/system dynamics modelling



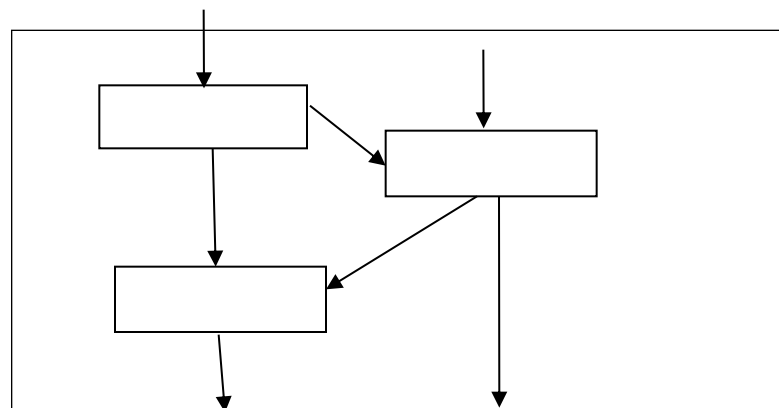
## Observed World



**Outcomes**

**Aggregated Outcomes**

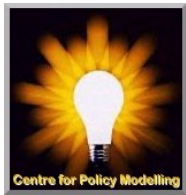
## Equation-based Model



**Aggregated Model Outcomes**



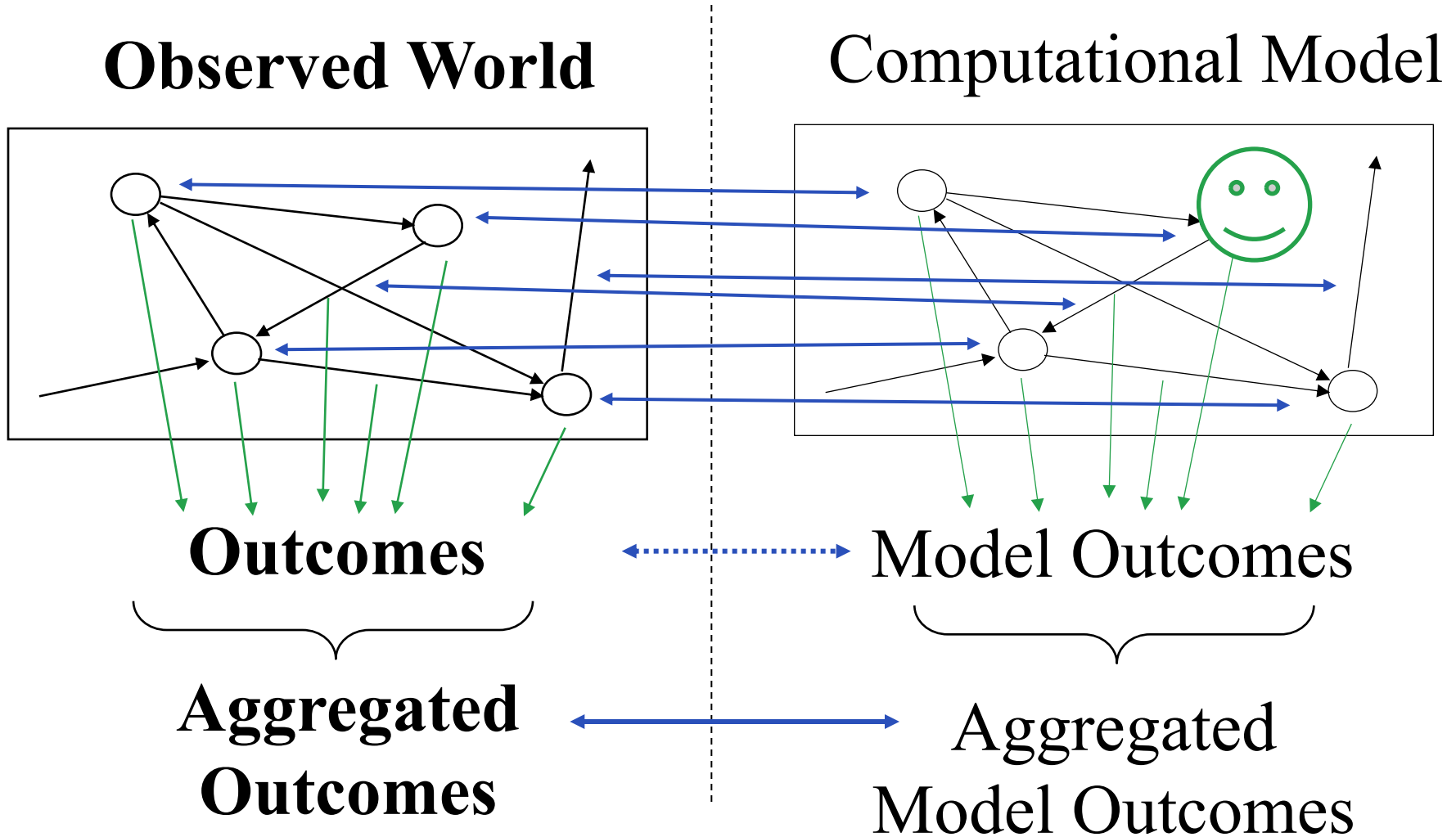
# Computational **models**



***Where a process is modelled in a series of precise instructions (the program) that can be “run” on a computer***

- The same program always produces the same results (essentially) but...
- ...may use a “random seed” to randomise certain aspects
- Can be simple or very complex
- Often tries to capture more “qualitative” aspects of social phenomena

# Agent-based simulation



# Characteristics of agent-based modelling



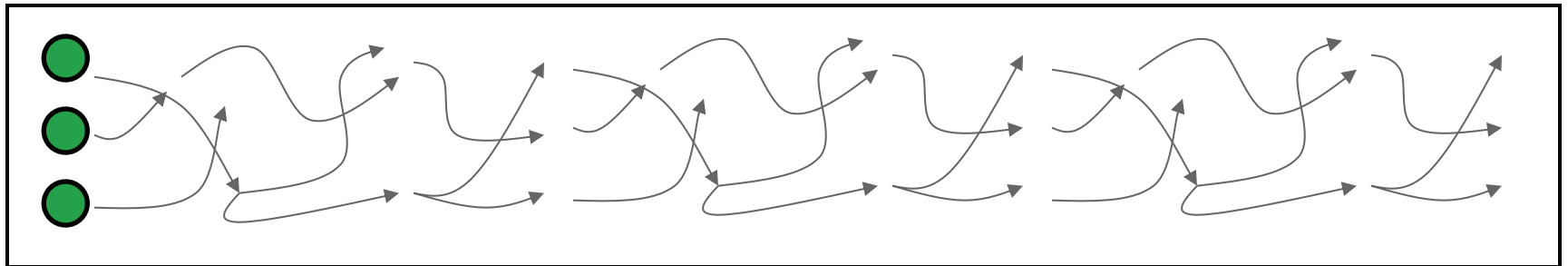
- Computational description of process
- Not usually analytically tractable
- More context-dependent...
- ... but assumptions are much less drastic
- Detail of unfolding processes accessible
  - more criticisable (including by non-experts)
- Used to explore inherent possibilities
- Validatable by data, opinion, narrative ...
- Often very complex themselves

# What happens in ABSS

- Entities in simulation are decided up
- Behavioural Rules for each agent specified (e.g. sets of rules like: if *this has happened* then *do this*)
- Repeatedly evaluated in parallel to see what happens
- Outcomes are inspected, graphed, pictured, measured and interpreted in different ways

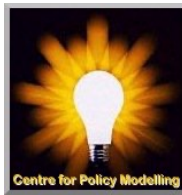
**Specification** (incl. rules)

**Representations of Outcomes**



**Simulation**

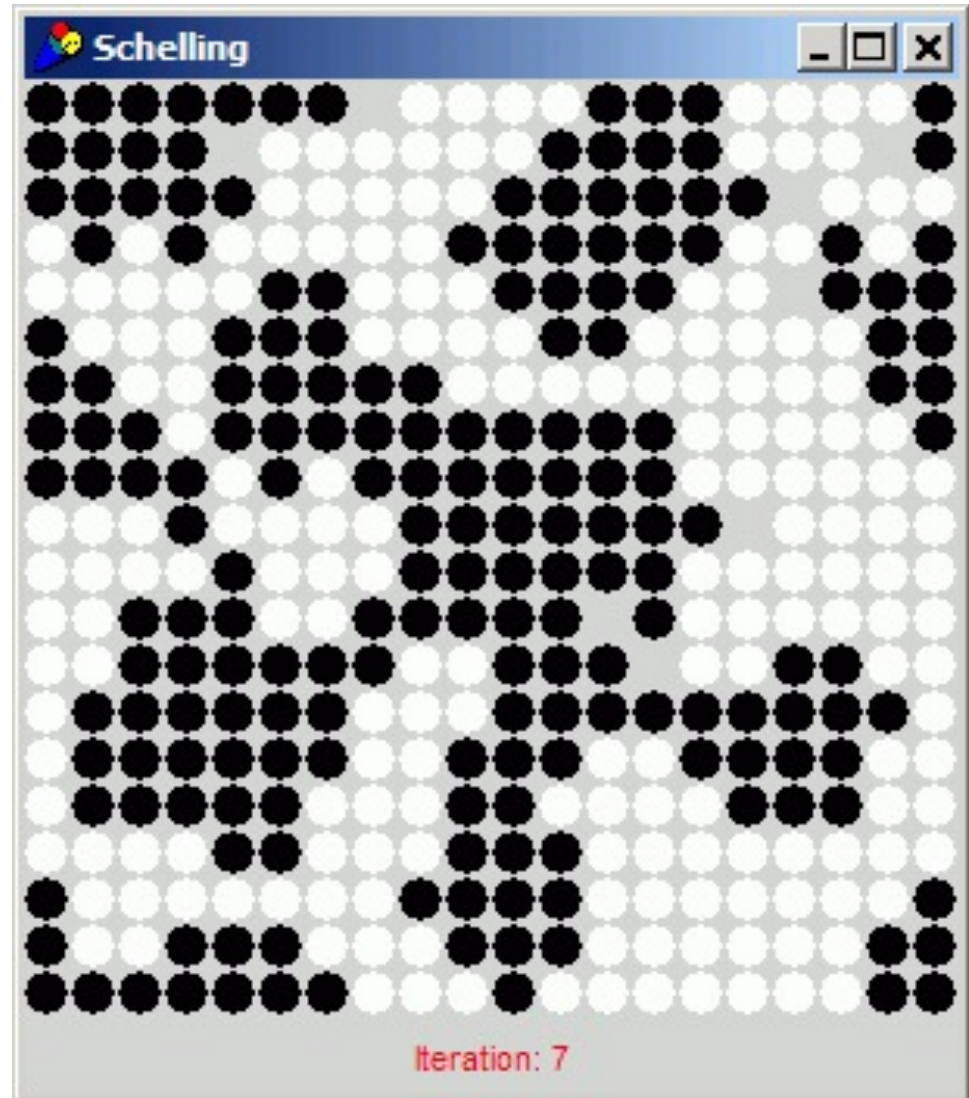
# Example 1: Schelling's Segregation Model



Schelling, Thomas C. 1971.  
Dynamic Models of Segregation.  
*Journal of Mathematical Sociology* 1:143-186.

**Rule:** each iteration, each dot looks at its neighbours and if less than 30% are the same colour as itself, it moves to a random empty square

**Conclusion:**  
*Segregation can result from wanting only a few neighbours of a like colour*

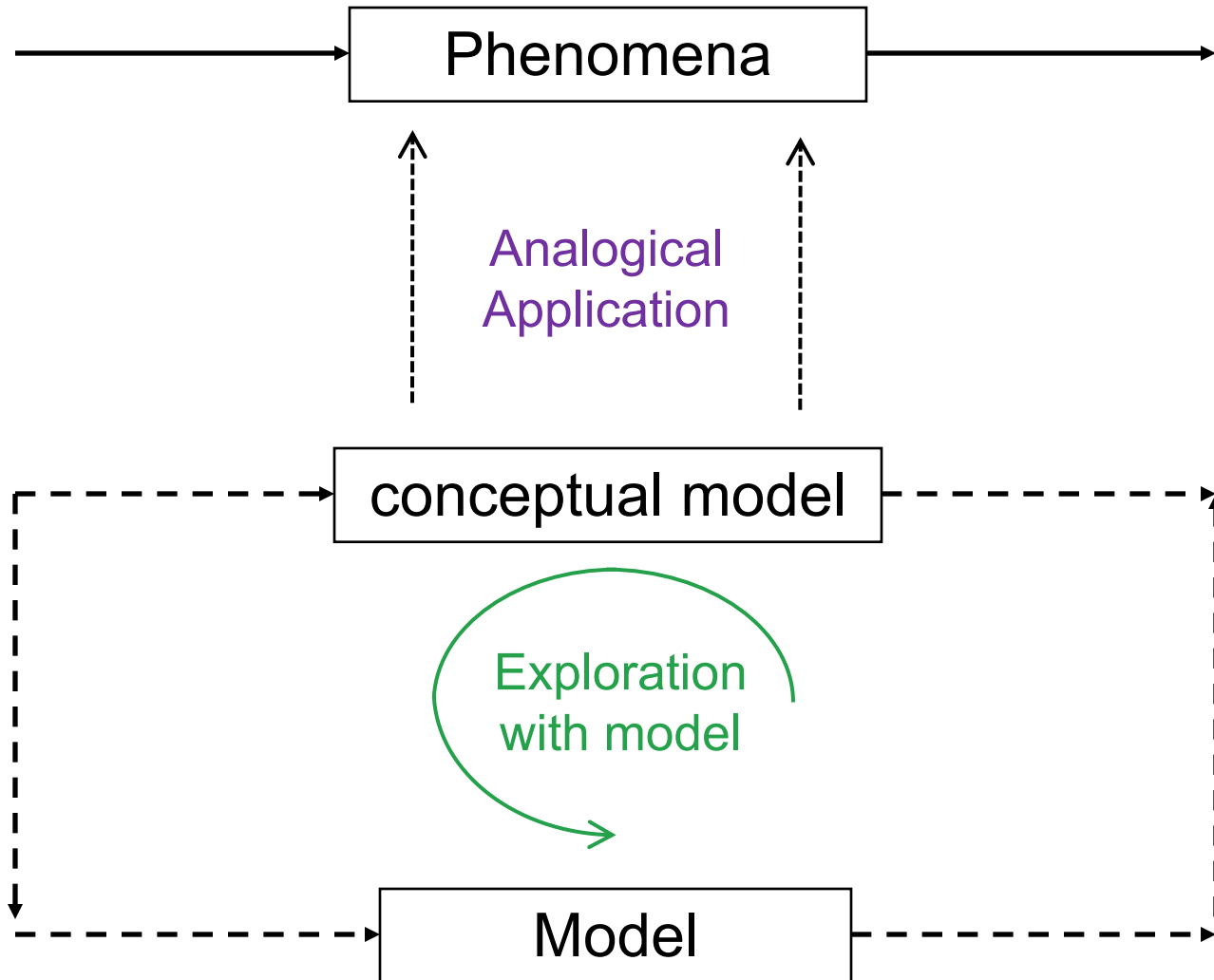
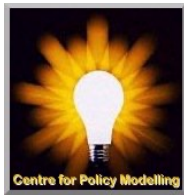


# Simple, Conceptual Simulations Such as Schelling's



- Are highly suggestive
- Once you play with them, you start to “see” the world in terms of your model – a strong version of Kuhn’s *theoretical spectacles*
- They can help persuade beyond the limit of their reliability
- They may well not be directly related to any observations of social phenomena
- Are more a model of an idea than any observed phenomena
- Can be used as a counter-example

# Modelling a concept of something



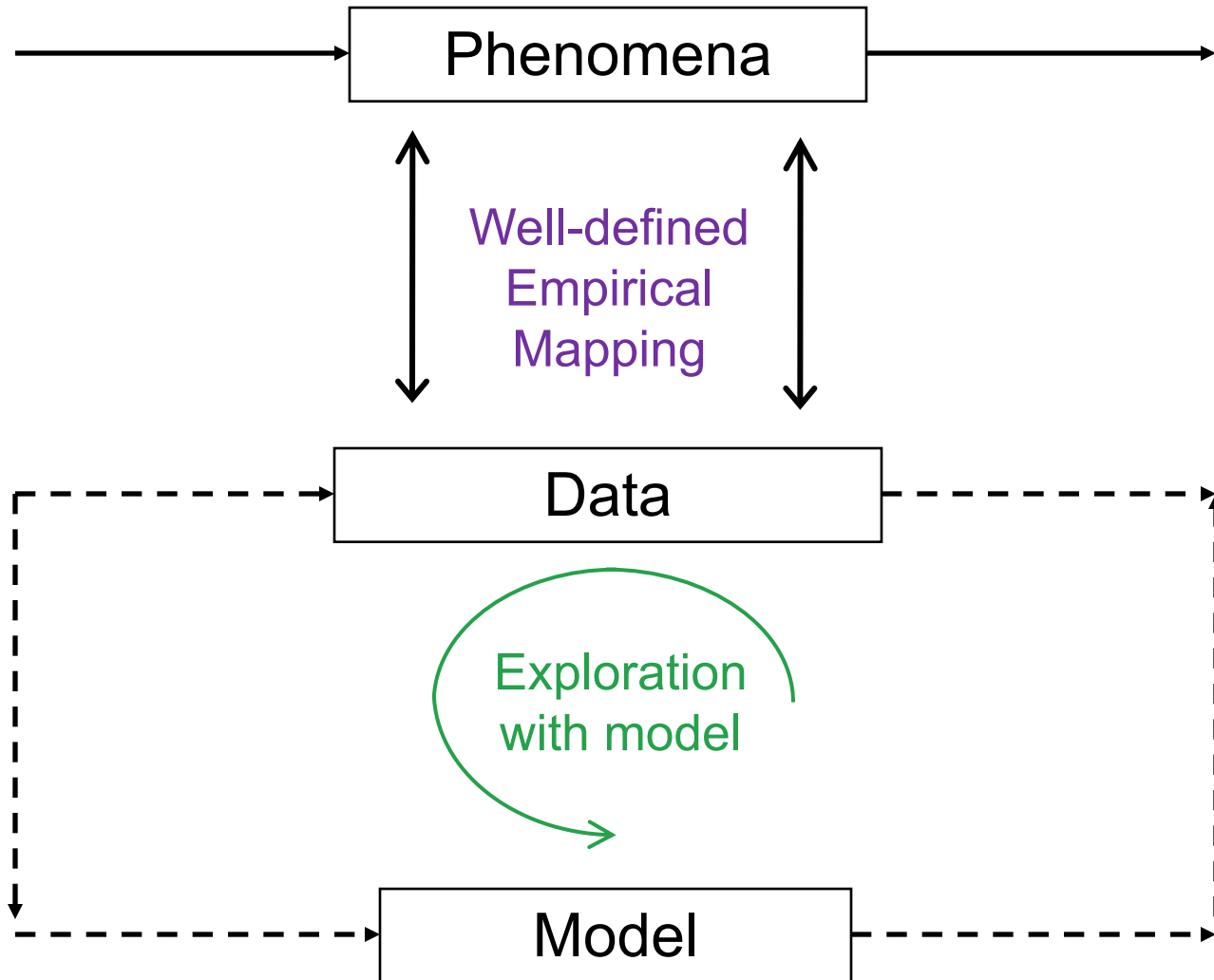
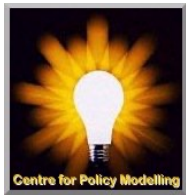
# Some Criteria for Judging a Model



Depends upon purpose of model!

- Soundness of design
  - w.r.t. knowledge of how the object works
  - w.r.t. tradition in a field
- Accuracy (lack of error)
- Simplicity (ease in communication, construction, comprehension etc.)
- Generality (when you can safely use it)
- Sensitivity (how much output changes)
- Plausibility (of design, process and results)

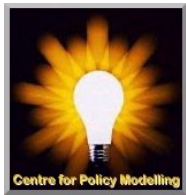
# Empirically modelling





# An Example

# **Example:** *A model of social influence and water demand*



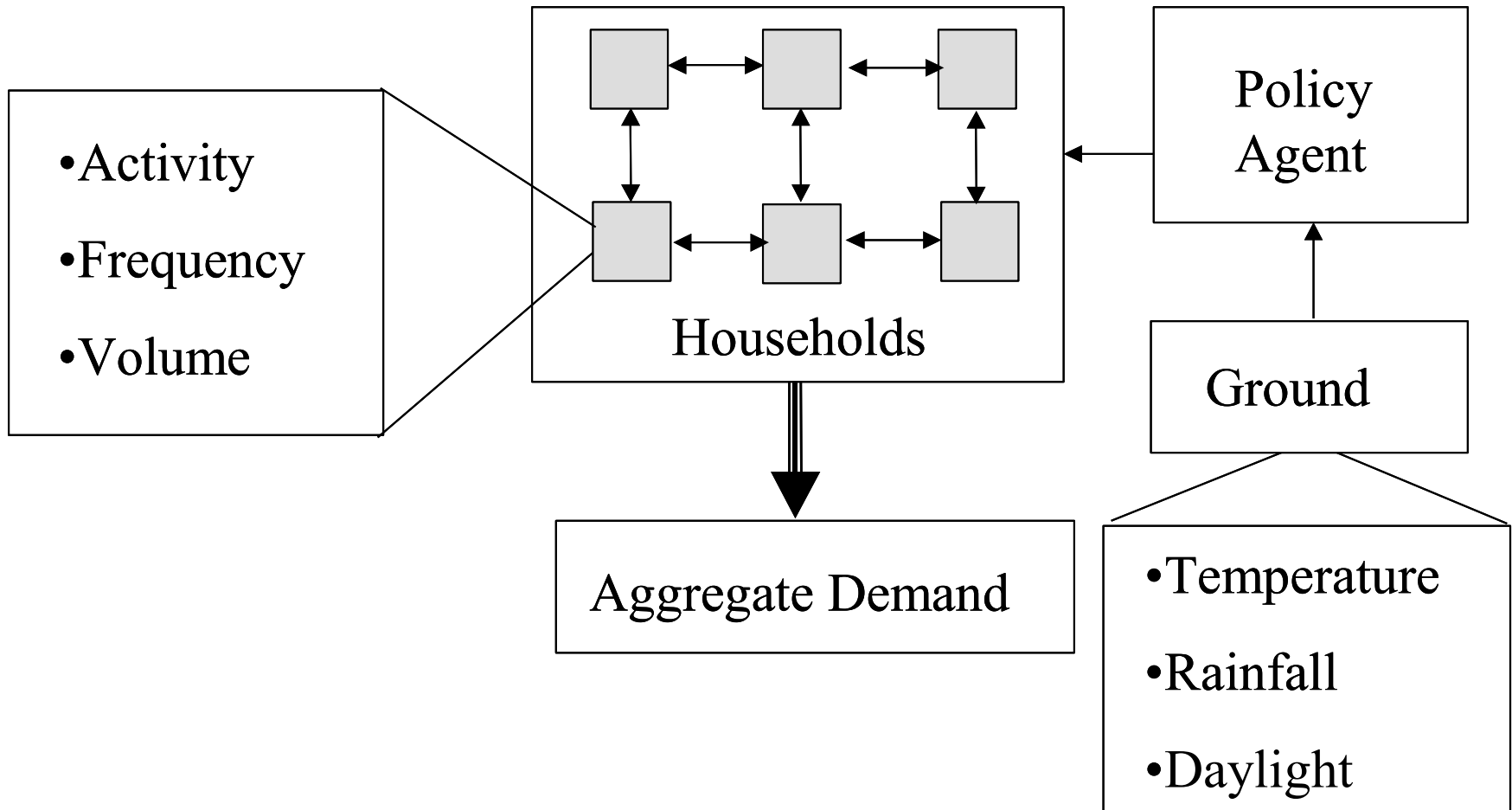
- Investigate the possible impact of social influence between households on patterns of water consumption
- Design and detailed behavioural outcomes from simulation validated against expert and stakeholder opinion at each stage
- Some of the inputs are real data
- Characteristics of resulting aggregate time series validated against similar real data



# Type, context, purpose

- **Type:** A complex agent-based descriptive simulation integrating a variety of streams of evidence
- **Context:** statistical and other models of domestic water demand under different climate change scenarios
- **Purposes:**
  - to critique the assumptions that may be implicit in the other models
  - to demonstrate an alternative

# Simulation structure



# Household Behaviour – Endorsement on Actions



- Each action might is a particular frequency and use of water
- Action Endorsements: recentAction neighbourhoodSourced selfSourced globallySourced newAppliance bestEndorsedNeighbourSourced
- 3 Weights moderate effective strengths of neighbourhoodSourced selfSourced globallySourced endorsements and hence the bias of households
- Can be simplified as 3 types of households influenced in different ways: *global*-; *neighbourhood*-; and *self*-sourced depending on the dominant weight

# History of a particular action from one agent's point of view with respect to one action



**Month 1:** used, endorsed as **self sourced**

**Month 2:** endorsed as **recent** (from personal use) and **neighbour sourced** (used by agent 27) and **self sourced** (remembered)

**Month 3:** endorsed as **recent** (from personal use) and **neighbour sourced** (agent 27 in month 2).

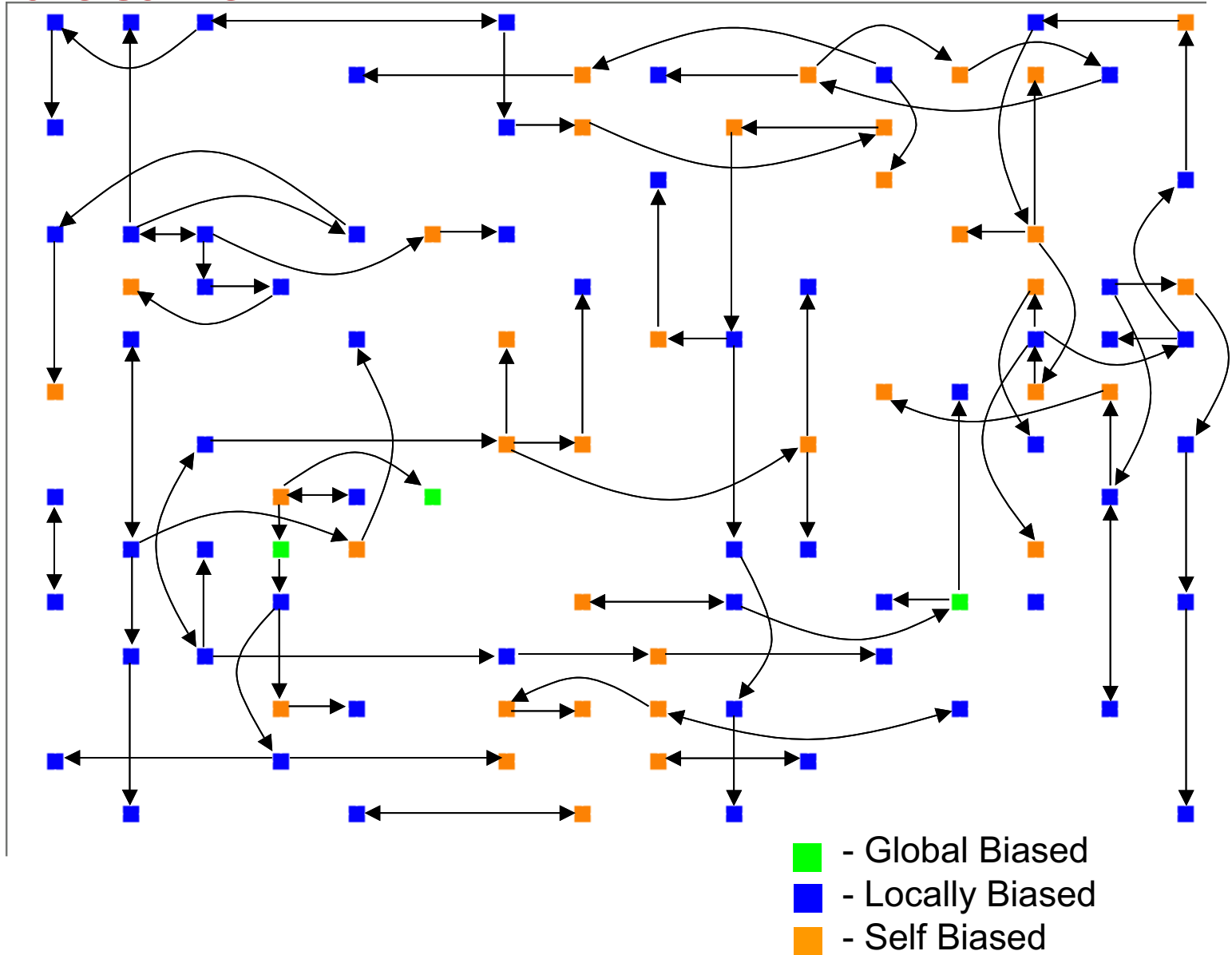
**Month 4:** endorsed as **neighbour sourced** twice, used by agents 26 and 27 in month 3, also **recent**

**Month 5:** endorsed as **neighbour sourced** (agent 26 in month 4), also **recent**

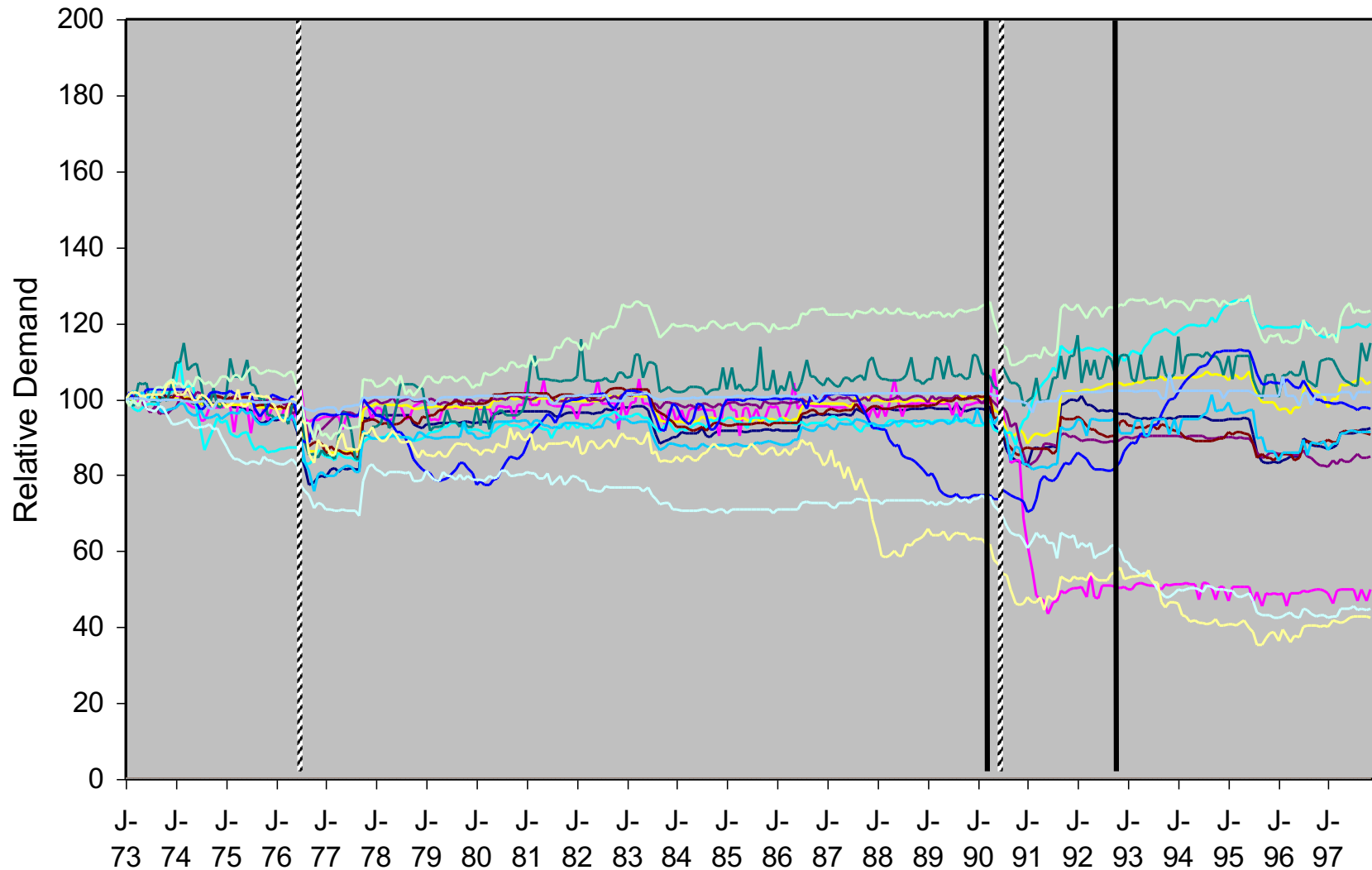
**Month 6:** endorsed as **neighbour sourced** (agent 26 in month 5)

**Month 7:** replaced by action 8472 (appeared in month 5 as **neighbour sourced**, now endorsed 4 times, including by the **most alike neighbour** – agent 50)

# Some of the household influence structure



# Example results

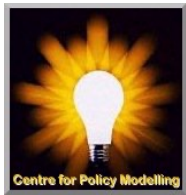


# Conclusions from Water Demand Example



- The use of a concrete descriptive simulation model allowed the detailed criticism and, hence, improvement of the model
- The inclusion of social influence resulted in aggregate water demand patterns with many of the characteristics of observed demand patterns
- The model established how it *was possible that* processes of mutual social influence could result in widely differing patterns of consumption that were self-reinforcing

# Comments on Descriptive ABSS



- Is a dynamic and integrated representation of available evidence of many different kinds: narrative, survey, time-series, SNA, etc. (a “*Data-Integration Model*”)
- More of a *description* than a general theory
- Allows for experimentation and exploration of possible outcome “trajectories”
- A main benefit is often the discovery of new questions and issues to be researched – it can inform good observational studies
- The simulation was complex and slow, we could not say we fully understand it
- Ideally the DIM should be subject to further analysis and modelling to check and understand aspects



# Conclusion

# Discursive vs Simulation Approaches



## Natural Language

- Rich, semantic, meaningful, flexible
- But imprecise
- Map to what is observed is often complex and implicit
- Difficult to keep track of complicated interactions and outcomes
- Has “pre-prepared” meaning and referents

## Computer Simulation

- Precise, well defined, replicable, flexible
- But brittle
- Semantically thin
- Map to observed *can be* explicit and more direct
- Good at keeping track of complicated interactions and outcomes
- Meaning needs to be established through use

# Analytic vs Simulation Approaches



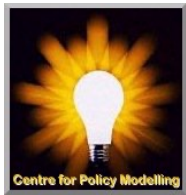
## Analytic Modelling

- Precise, well defined, replicable
- Very brittle
- Not Semantic
- Map to observed can be indirect and/or difficult to establish
- Strong checkable inference
- General characterisation of outcomes
- Requires *strong* assumptions to work

## Computer Simulation

- Precise, well defined, replicable, flexible
- More expressive descriptive
- Semantically thin
- Map to observed *can be* explicit and more direct
- Inference is more contingent, (sets of) example outcomes
- Can relate more easily to a broader range of evidence

# What ABSS Can Do



- ABSS can allow the production and examination of sets of possible complicated processes both emergent and immergent
- Using a precise (well-defined and replicable) language (a computer program)
- But one which allows the tracing of very complicated interactions
- And thus does not need the strong assumptions that analytic approaches require to obtain their proofs
- It allows the indefinite experimentation and examination of outcomes (*in vitro*)
- Which can inform our understanding of some of the complex interactions that may be involved in observed (*in vivo*) social phenomena



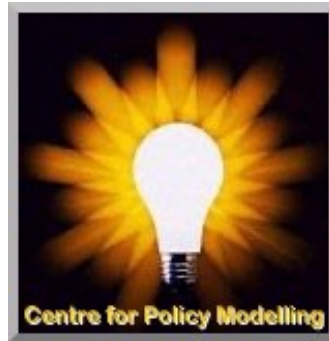
# To Learn More

- *Simulation for the Social Scientist*, 2<sup>nd</sup> Edition. Nigel Gilbert and Klaus Troitzsch (2005) Open University Press.  
<http://cress.soc.surrey.ac.uk/s4ss/>
- *Journal of Artificial Societies and Social Simulation*, <http://jasss.soc.surrey.ac.uk>
- *European Social Simulation Association*, <http://essa.eu.org>
- *NetLogo*, a relatively accessible system for doing ABSS with a big library of example models, <http://ccl.northwestern.edu/netlogo>

# The End

For supporting information follow links:

<http://methods.manchester.ac.uk/methods/abss>



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Centre for Policy Modelling

<http://cfpm.org>

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