Simulating social phenomena:
the middle way

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Agents

- Distinct parts of a computer program, each of which represents a social actor
- Agents may model any actors
  - Individuals
  - Firms
  - Nations
  - etc.
- Properties of agents
  - Perception
  - Performance
  - Policy
  - Memory

Interaction

- Agents are not isolated
- Information passed from one agent to another
  - (coded) Messages
  - Direct transfer of Knowledge
  - By-products of action e.g. chemical trails or *pheromones*
  - Etc.

Environment

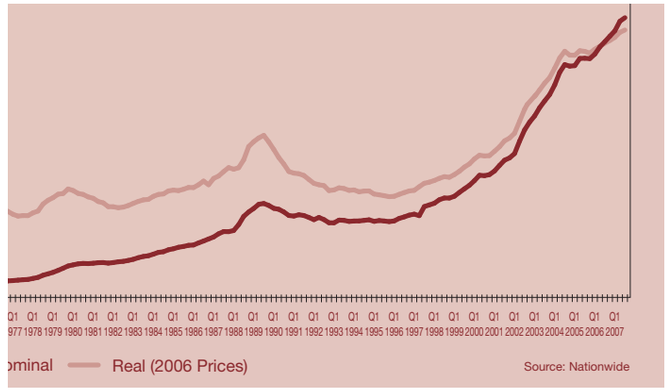
- Options:
  - Geographic space
  - Analogues to space e.g. knowledge space
  - Network (links, but no position)
- The environment provides
  - Resources
  - Communication

An example: modelling the housing market

- Hugely important to national economies
  - in UK, NL, ES, US etc.
- Housing in these countries is a major component of personal wealth, as well as just a place to live
  - affecting consumption, inheritance, mobility etc.
- A special market
  - location important
  - infrequent purchase
  - many parties
    - buyer, seller,
    - estate agent/realtor,
    - bank

Previous work

- Mostly econometric models
  - used to produce quantitative house price projections
  - based on trends in incomes, interest rates and housing supply
  - little opportunity to consider spatial element of market
  - provides little understanding of the mechanics of the market
  - unable to deal with anticipating the effect of policies that might change the character of the market
    - e.g. new taxes
    - new sources of finance
    - ...
- Land use models
  - don't usually attend to the special financial aspects of the housing market



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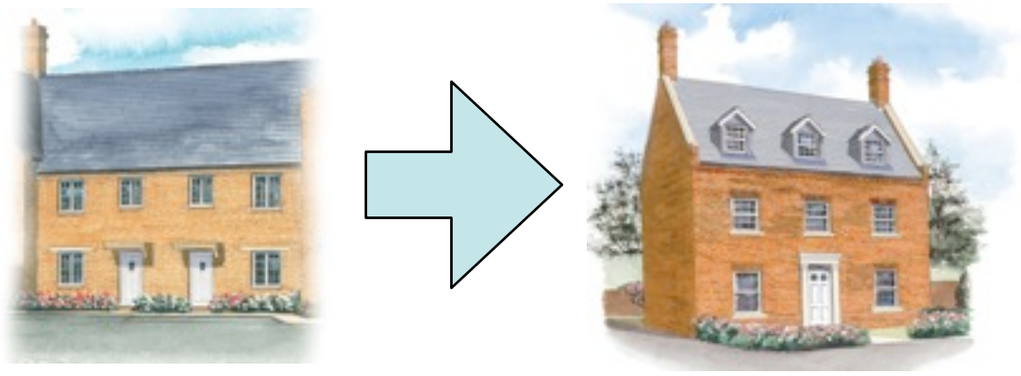
How to sell a house (in England*)

- get a valuation from several local estate agents (realtors)
- decide on one agent, and put house on market at the proposed price
  - (the agent gets a commission on sales, usually of around 3%)
- wait for offers
  - which may be less than the asking price
- accept one offer
- find somewhere to move to
  - (see how to buy a house, next slide)
- move

*and Wales

How to buy a house in England

- search for a house you like and can afford
- make an offer
- wait for it to be accepted
  - (if not accepted, because the offer price is too low, or someone else has got there first, go back to searching)
- if you have a house to sell, put it on the market
- when the chain is complete, exchange contracts
- move



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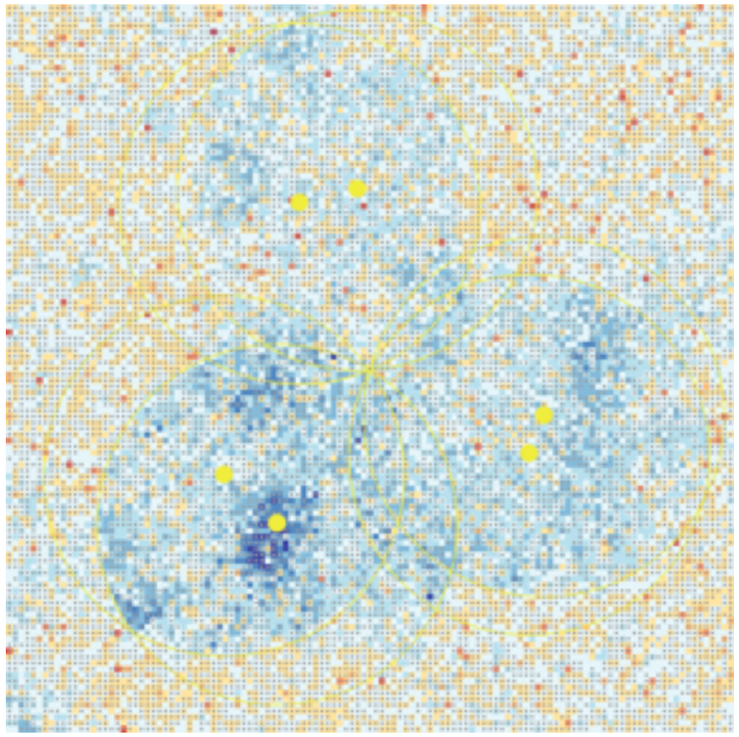
The model

- An 'abstract' model
  - no specific geography, just a regular grid
  - all houses are owned (no rental sector)
  - time steps represent (roughly) a quarter of a year
- Households move:
  - when they enter the town
  - when they exit the town
  - when their mortgage repayments become too expensive to afford
  - when their mortgage payments become much too low compared with their income, and they can afford a more expensive property
- Households who cannot find a suitable property become discouraged and eventually exit from the town

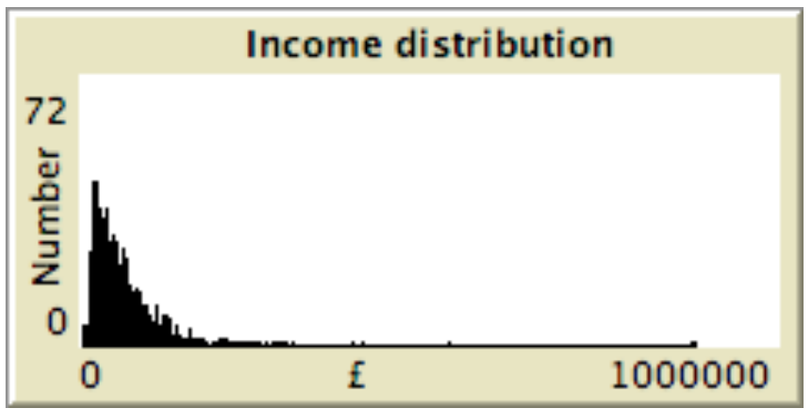


Agent behaviour

- Buyers
  - look for a house that best fits their income and make an offer
- Sellers consult local estate agents (= 'realtors') for valuations
  - put their house on the market at the highest valuation
  - reduce the price gradually if it does not sell
  - accept the first offer that matches the asking price
- Realtors base their valuations on their history of recent sales in their locality
- Sales only occur if there is an unbroken chain:
  - e.g a newcomer buys the house of *Household 1*, which buys the house of *Household 2*, which which buys the house of *Household 3*, which exits from the town

Households

- At each time step, homeowners have
  - an income
    - randomly drawn from a Gamma distribution
  - a chance of getting an income shock (± 20%)
    - this raises or lowers their income
    - consequence: they have to (or want to) move
  - a chance of having to leave town
    - if they are discouraged buyers
    - if they want to emigrate



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Realtors

- There are six realtors, distributed around the town
- Each has a territory within which they operate
  - the territories overlap
- Realtors know the sales prices of the houses that they have sold and use these as the basis for valuing houses newly put on sale
- Valuations are boosted by a Realtor Optimism factor (e.g. 3%),
  - because the realtors hope that they can get more than their previous experience implies

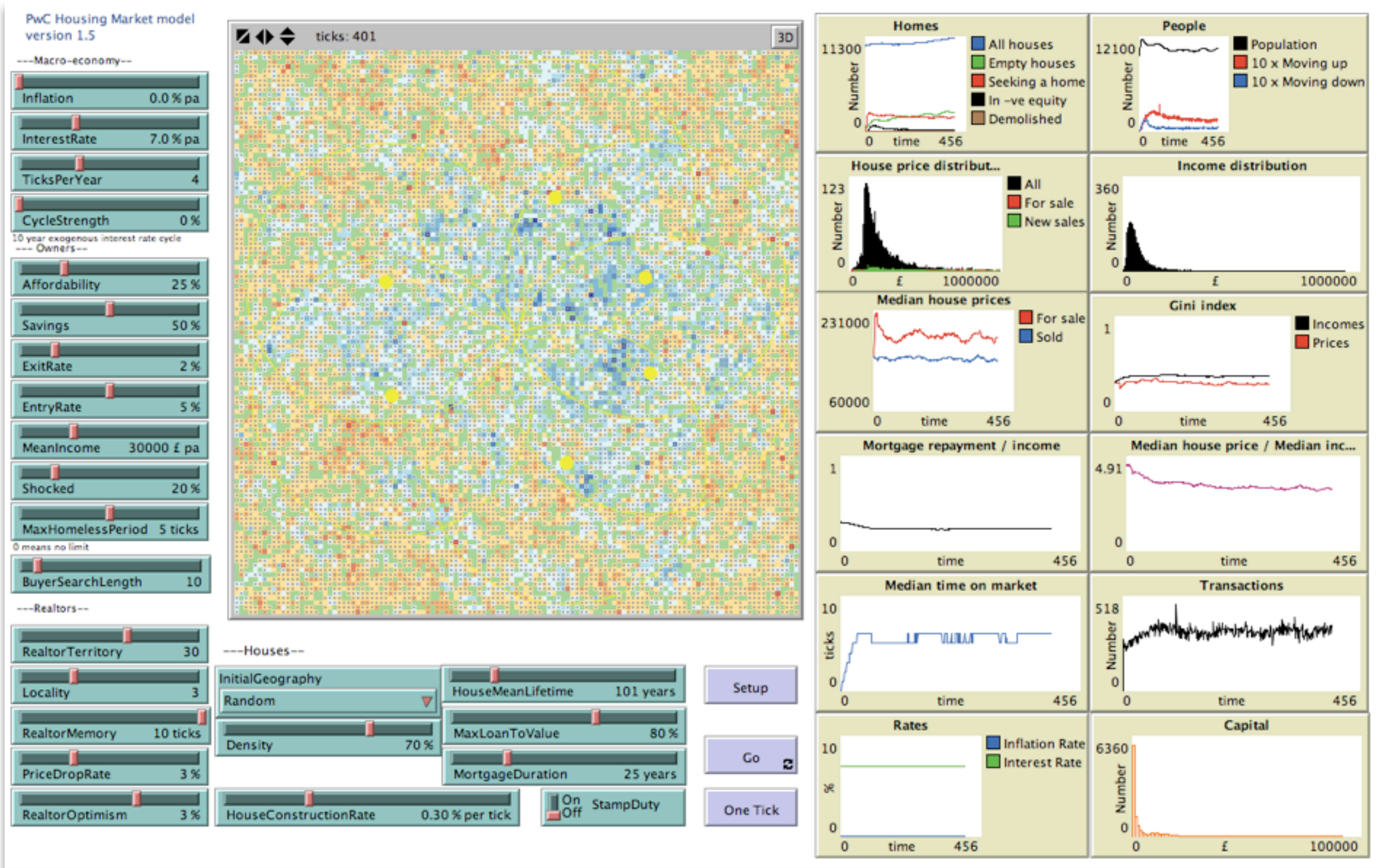
Buyers

- Households can accumulate capital from selling their previous house; this can be put towards the cost of their new house
- Households usually need to borrow to buy a house
  - they can borrow an amount such that their repayments do not exceed a proportion (the 'Affordability', e.g. 25%) of their income

Sales

- When a house is sold,
  - the seller gets the price of the house
  - pays back the mortgage to the bank
  - keeps any surplus
- If the price offered is less than the sellers' mortgage, the sale is void
  - the seller has *negative equity*
  - and cannot sell until the price received is more than the remaining mortgage

The simulation



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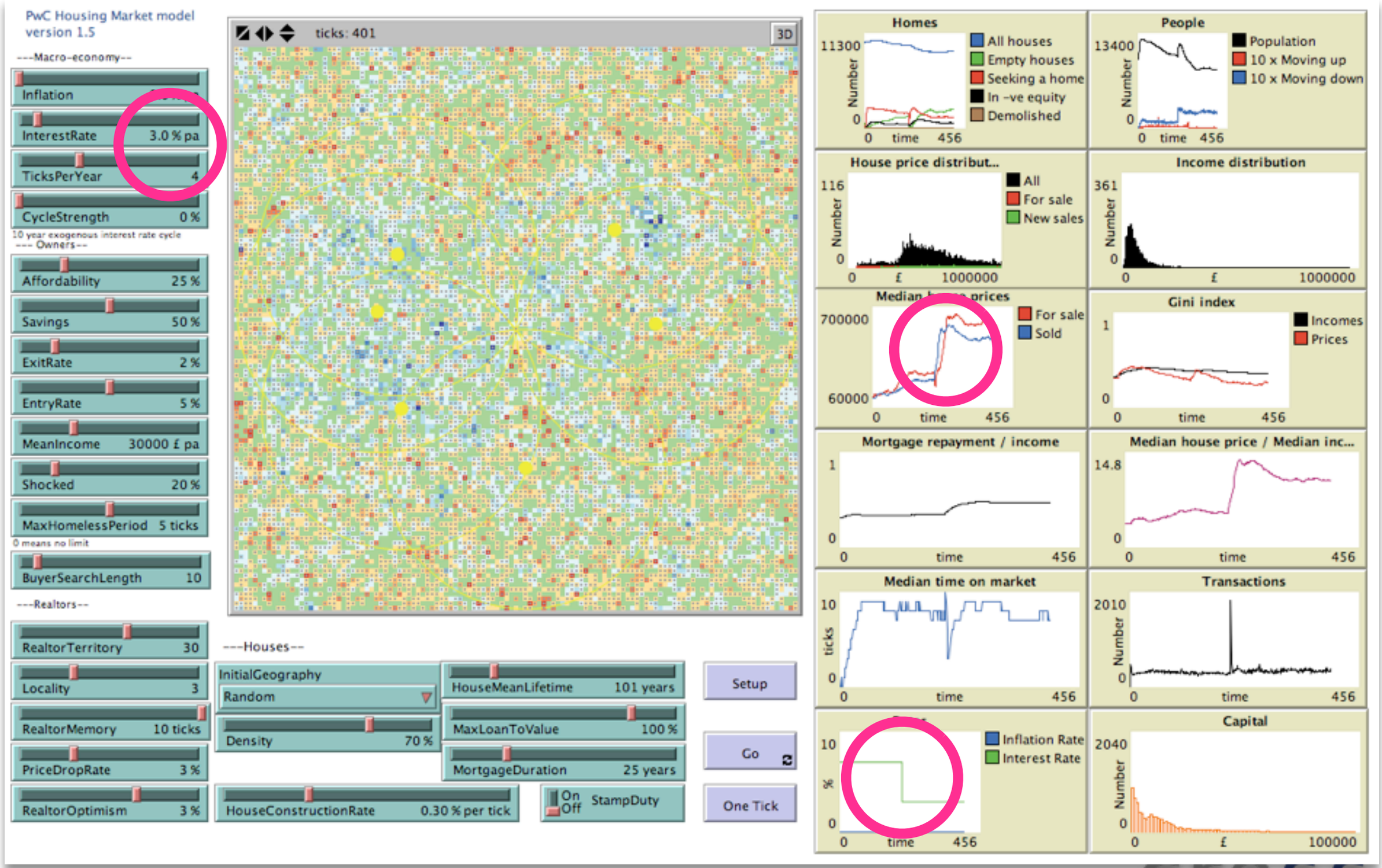
Individual behaviour leading to macro-level patterns

- We have agents with plausible individual (micro) behaviour
- Do plausible patterns emerge at the macro level?

Lowering the mortgage interest rate



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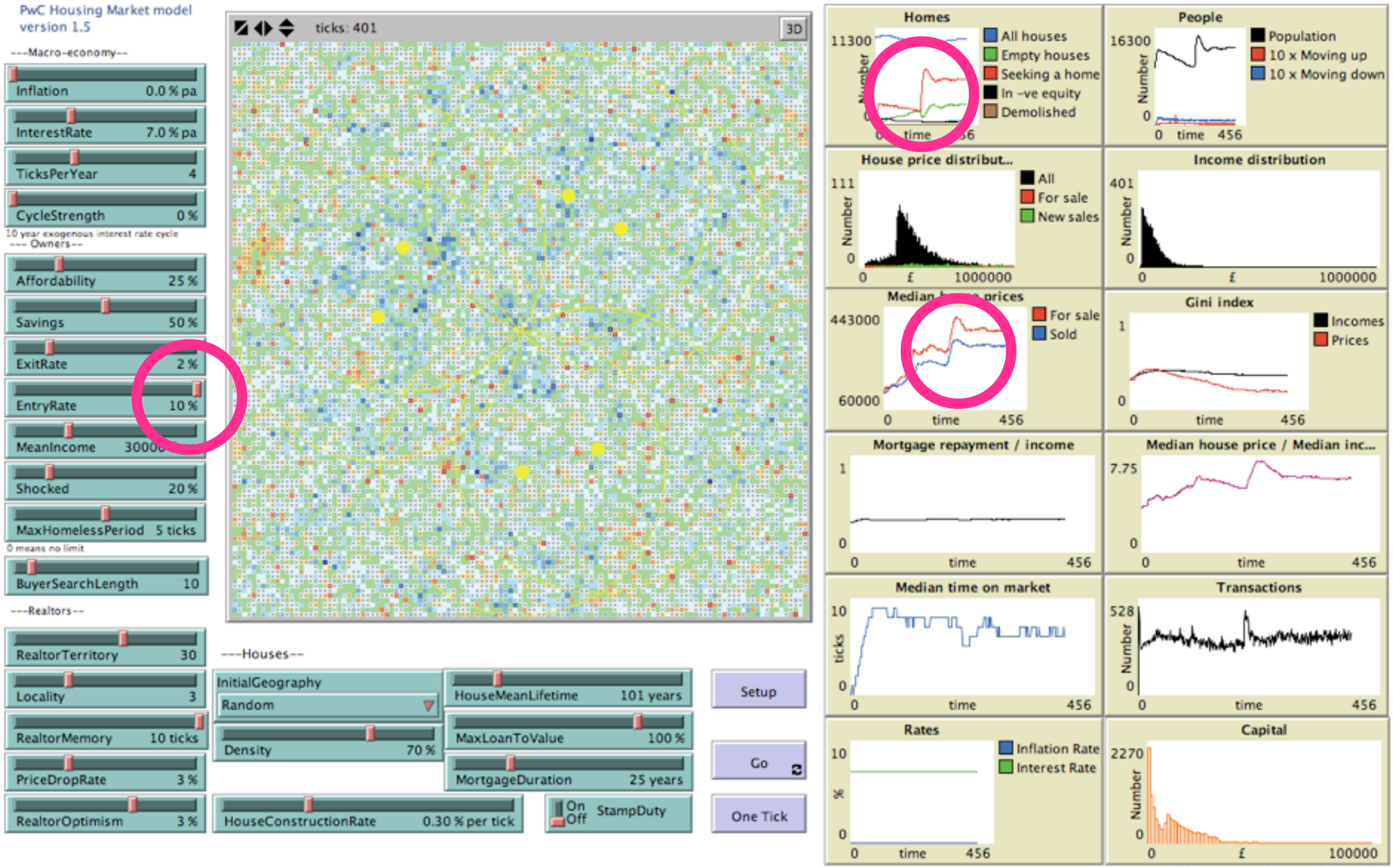
Influx



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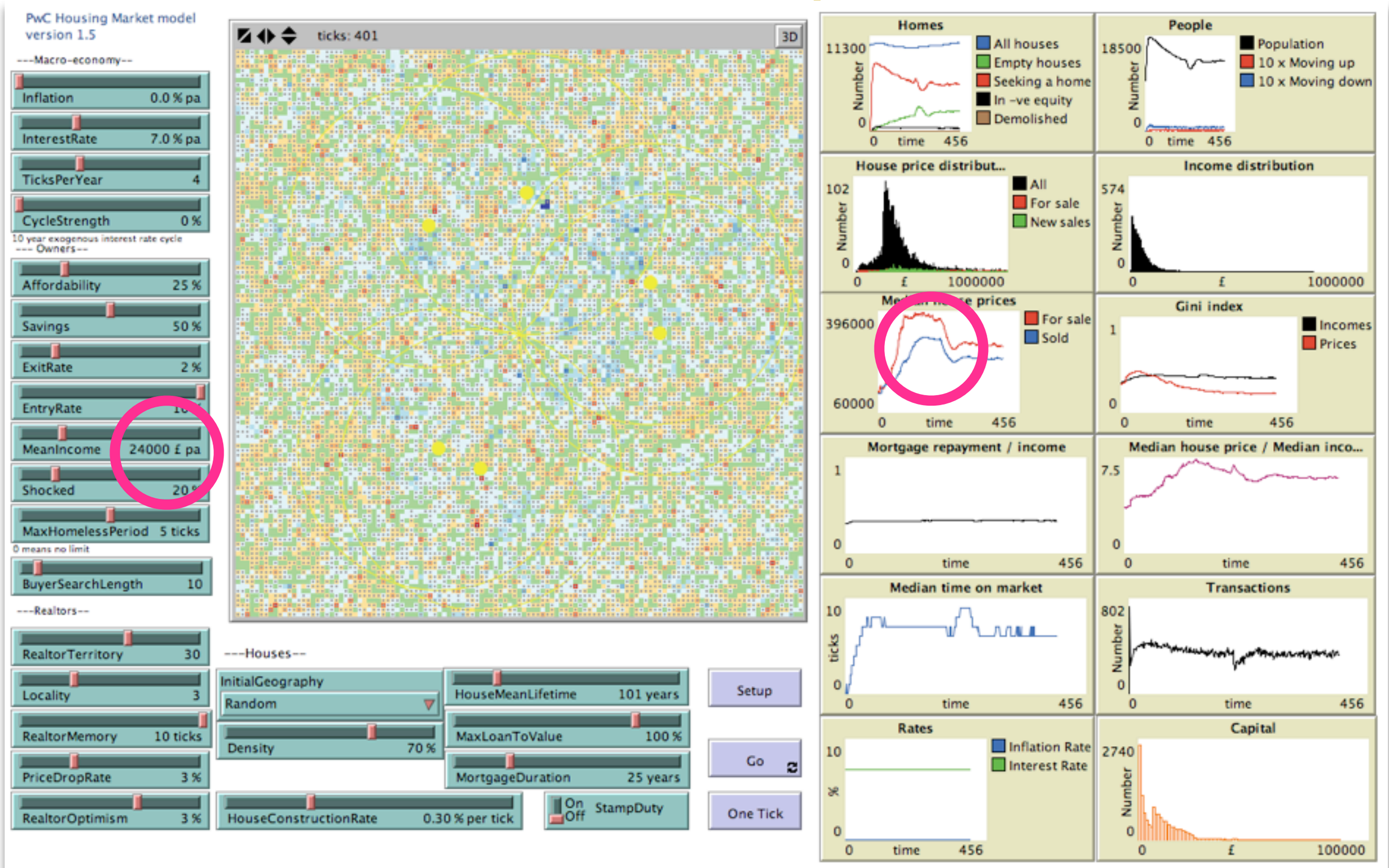
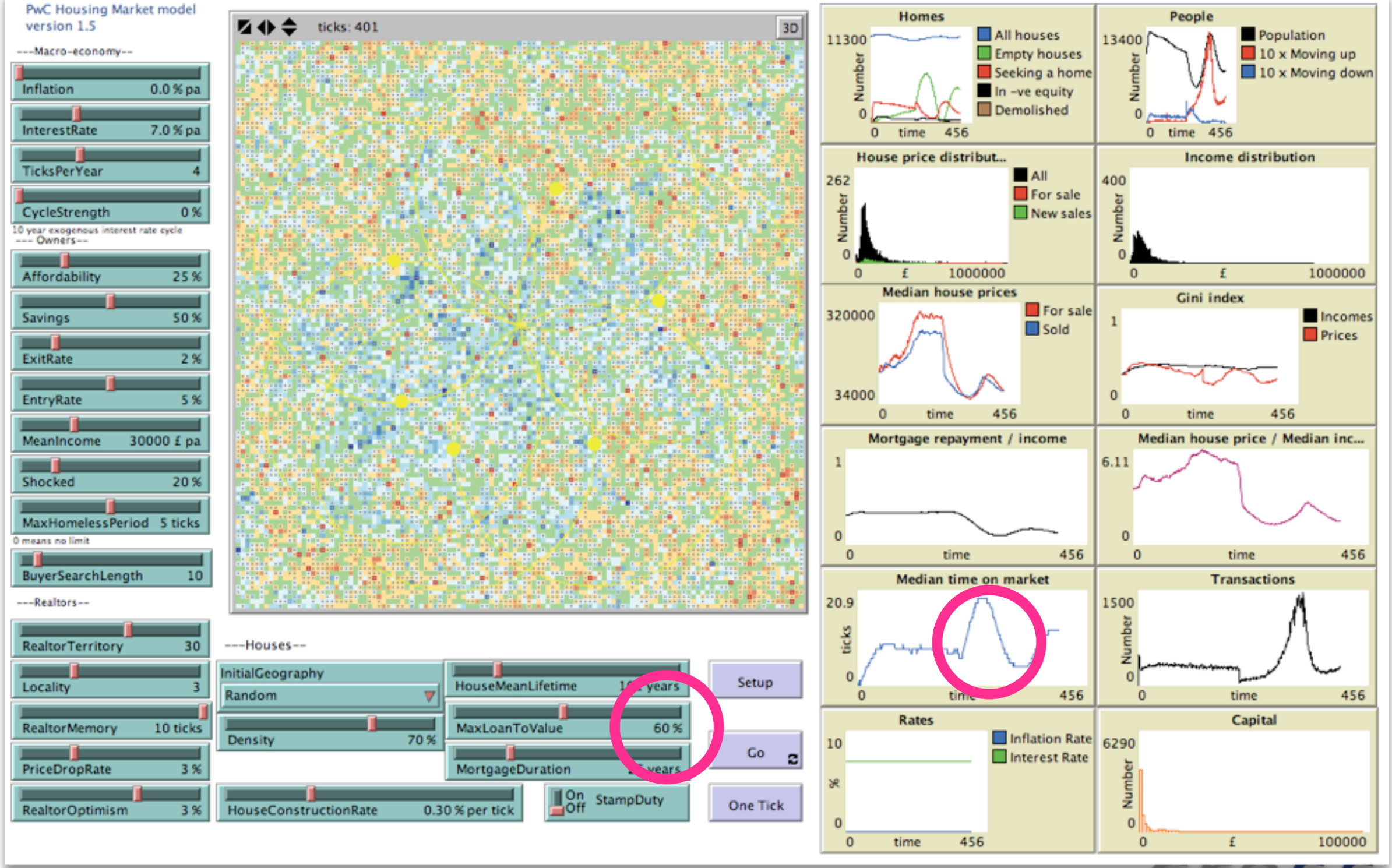
Prices out of reach of first-time buyers



The credit crunch



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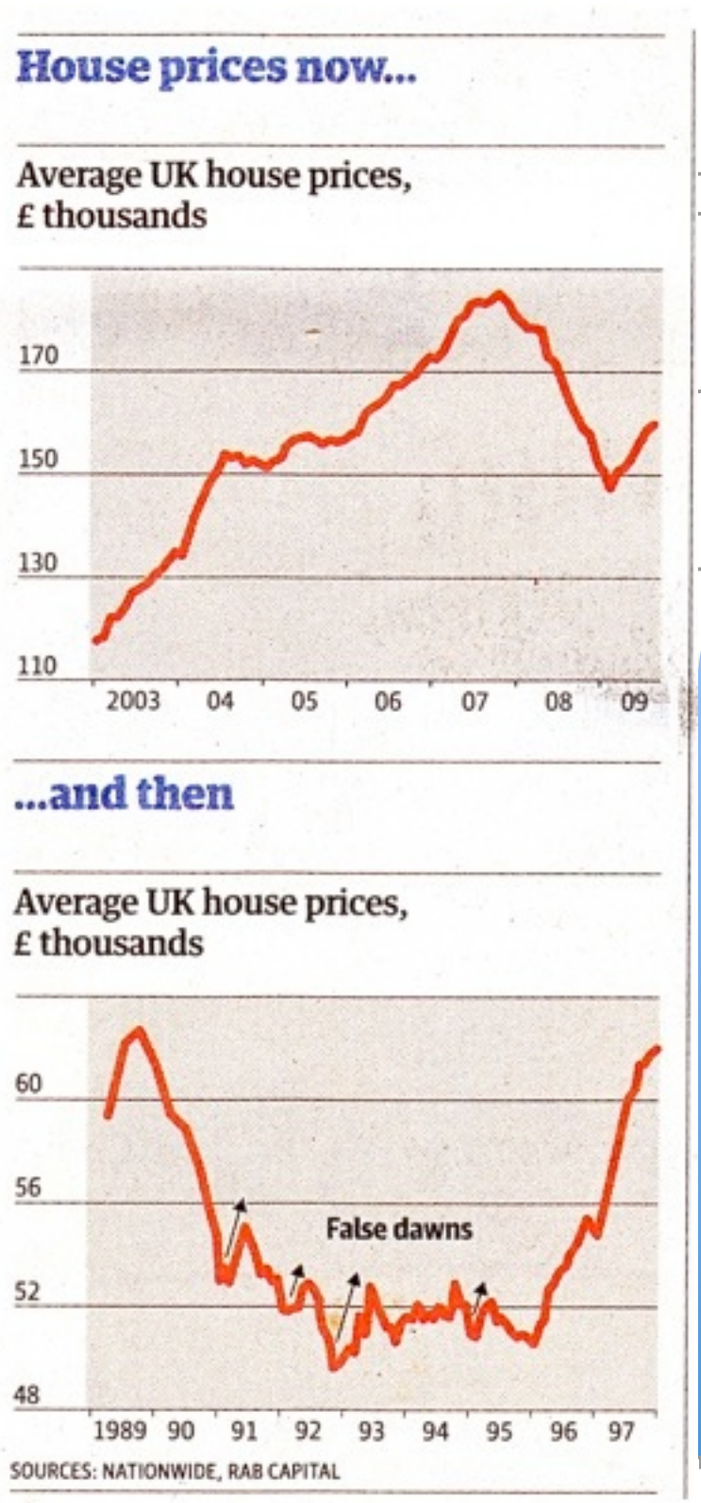
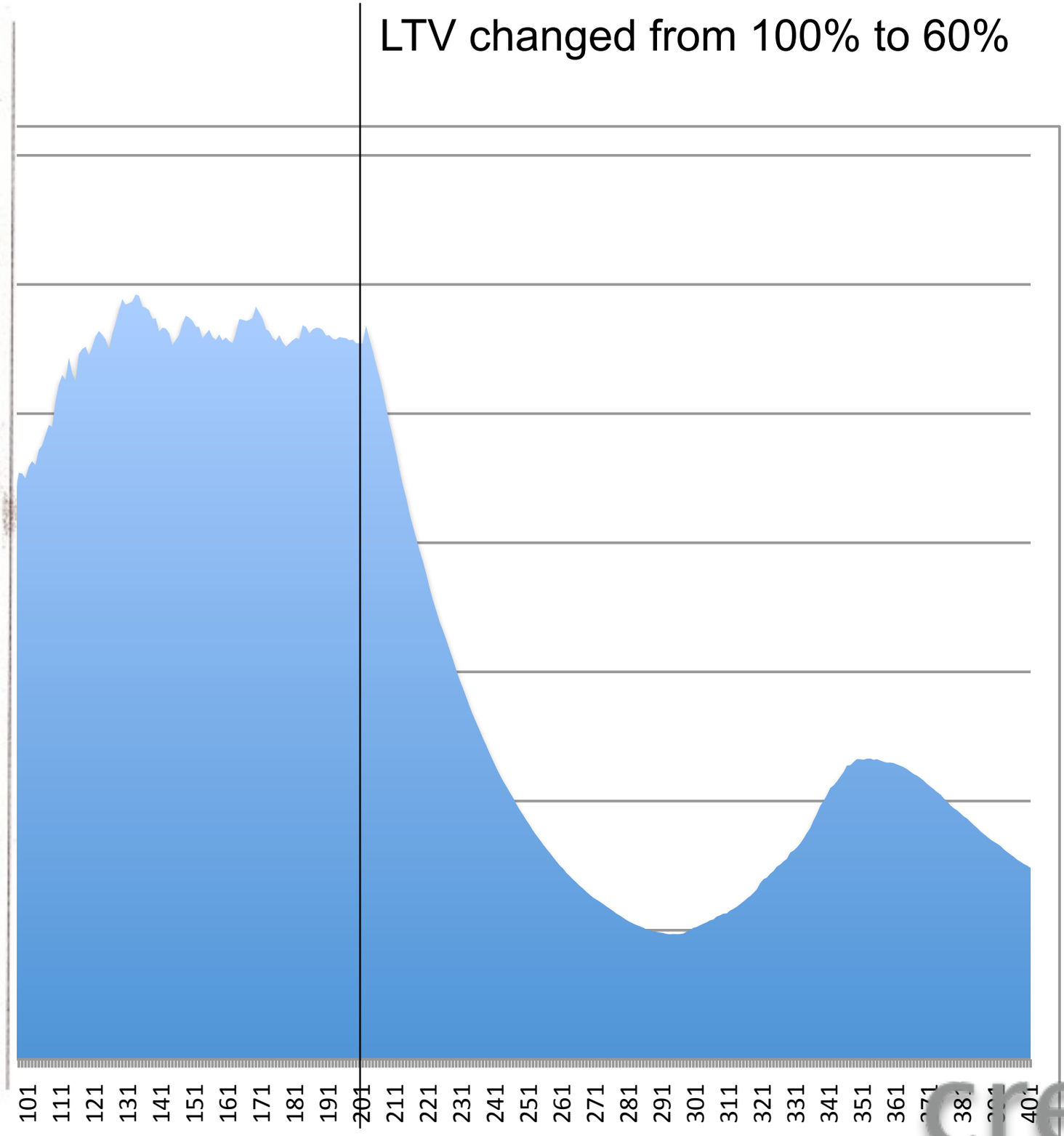
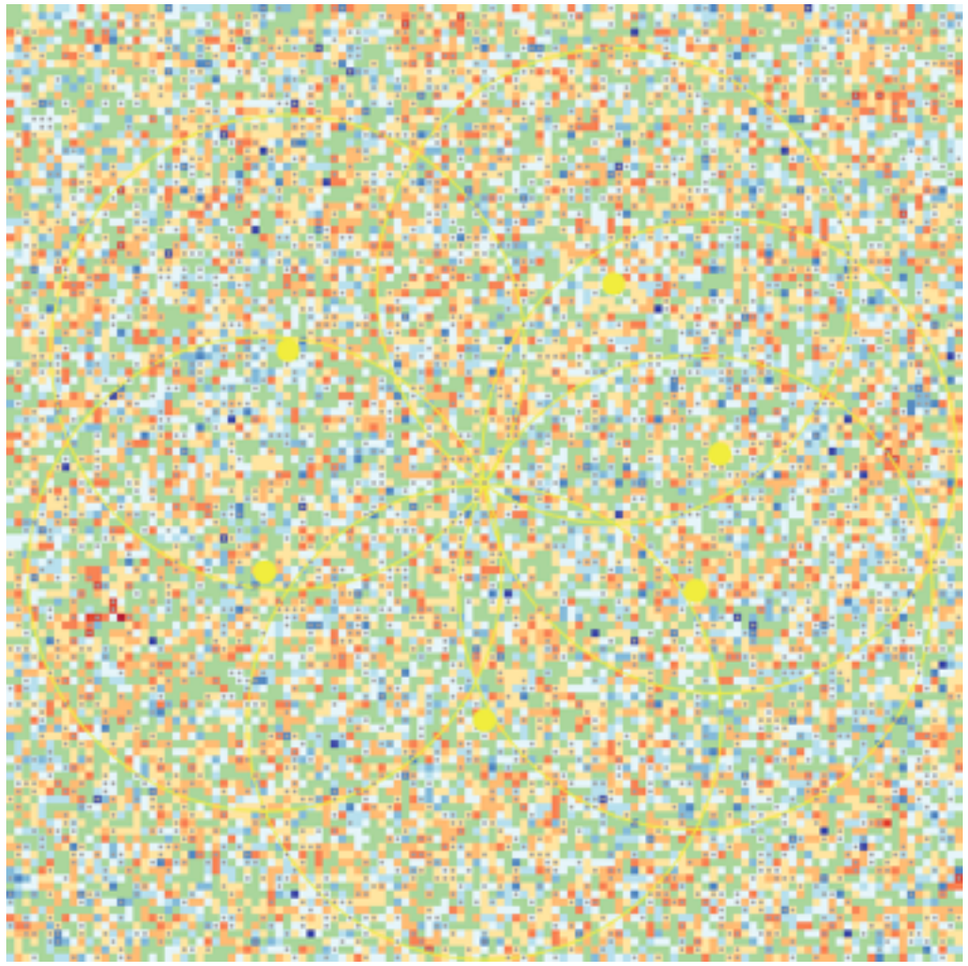
A bounce


House prices now...
Average UK house prices, £ thousands
170
150
130
110
2003
04
05
06
07
08
09
...and then
Average UK house prices, £ thousands
60
56
52
48
False dawns
1989
90
91
92
93
94
95
96
97
SOURCES: NATIONWIDE, RAB CAPITAL

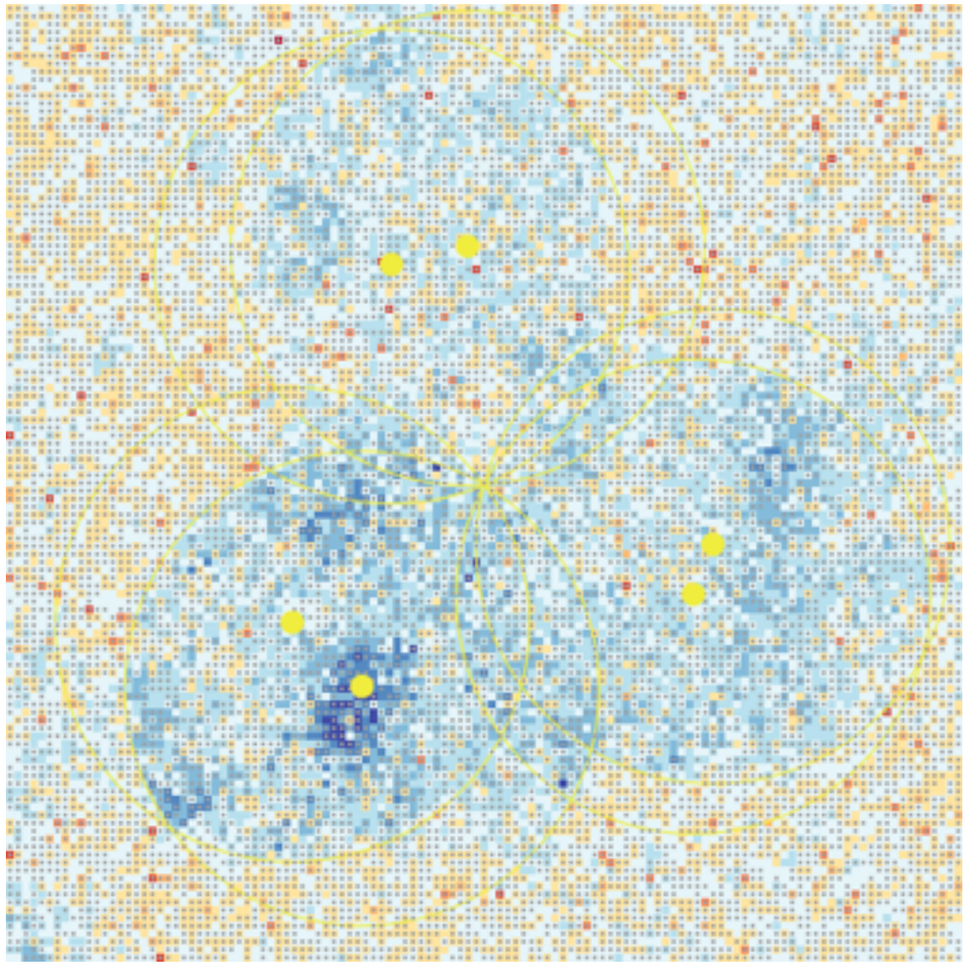

LTV changed from 100% to 60%
101
111
121
131
141
151
161
171
181
191
201
211
221
231
241
251
261
271
281
291
301
311
321
331
341
351
361
401

- Why don't the current very low mortgage interest rates lead to higher house prices?
- Because the more stringent loan-to-value requirement decreases the demand, especially from first-time buyers and this chokes the market

Emergent neighbourhoods



Random at time 0



At time 3000

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What's missing

- The rental sector
  - but, to a first approximation, rents track mortgage payments
- Endogenous house construction
  - at present house construction is at a constant user-set rate
  - it should increase and decline according to the state of the market (with a time lag)
- Endogenous mortgage rates
  - the mortgage interest rate is at a constant user-set rate
  - it should react (to some extent) to the demand for mortgages
- Competition for business between realtors

What's missing (on purpose)

- Real geography
- Social networks
  - no representation of friends and family
- Demographics
  - no representation of births, marriages and deaths
- (Rational) expectation
  - no representation of anticipated price rises and falls
  - no speculators

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Reflections

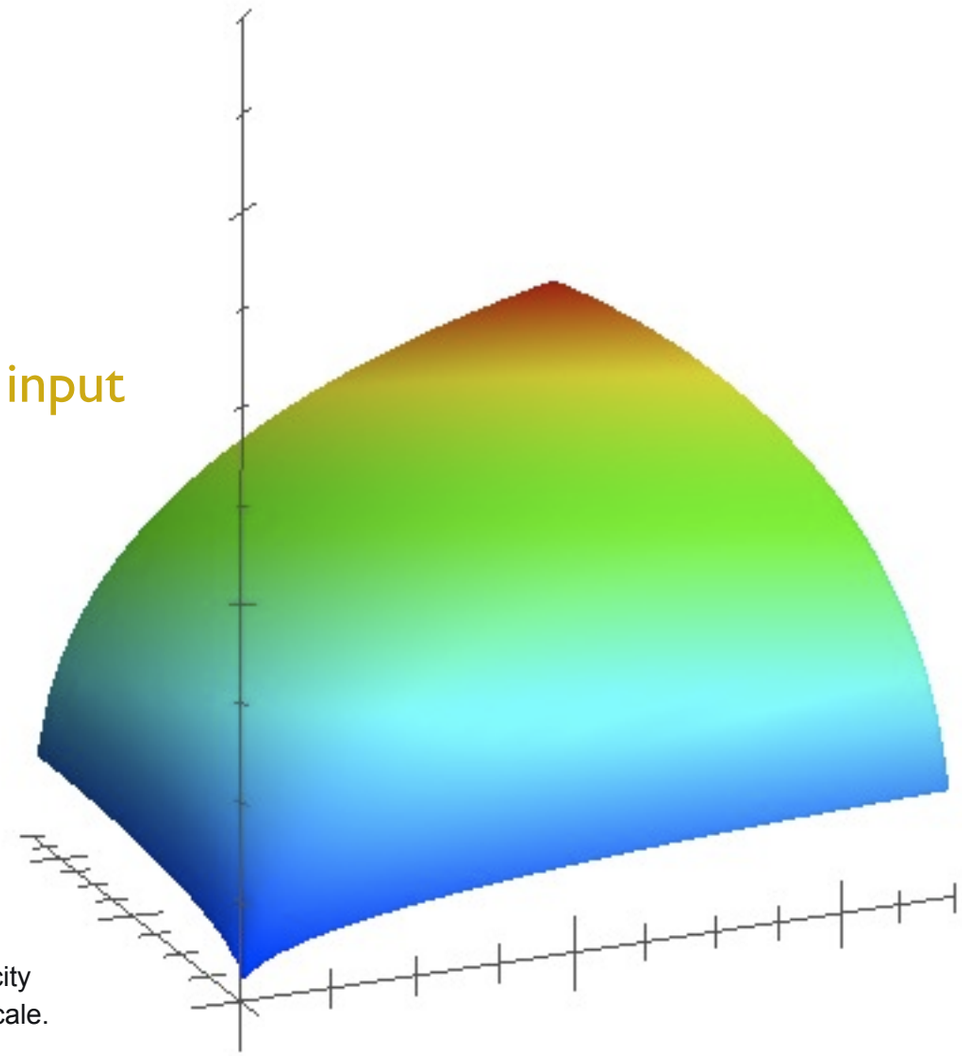
The characteristics of simulation

- Process analysis
  - –not just at one moment in time
- Abstraction
  - –not just descriptive
- Macro and micro
  - –not just individual/atomistic
- Experimental
  - –not just observational

Types of models

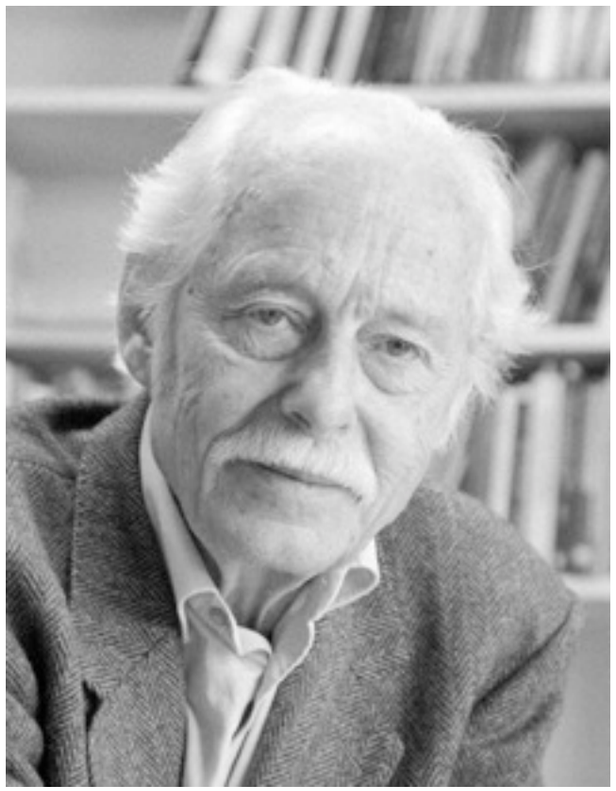
- Inductive models
  - unsupervised learning
  - statistical clustering

- Mathematical models
  - Cobb-Douglas production function
  - $Y = aL^{\alpha}K^{\beta}$,
    - Y = output, L = labour input, K = capital input



(CC) Image: Paul Schächterle
Cobb-Douglas production function with 2 factors and production elasticity complying to the neoclassical LDR, i.e. overall decreasing returns to scale.

Generative social science



- "Explanation is not achieved by a description of the patterns of regularity, no matter how meticulous and adequate, nor by replacing this description by other abstractions congruent with it, but by exhibiting what makes the pattern, i.e., certain processes. To study social forms, it is certainly necessary but hardly sufficient to be able to describe them. To give an explanation of social forms, it is sufficient to describe the processes that generate the form".

Barth, Fredrik. 1981. *Process and Form in Social Life: Selected Essays of Fredrik Barth*. London: Routledge & Kegan Paul, pp 35-36

- "Situate an initial population of autonomous heterogeneous agents in a relevant spatial environment; allow them to interact according to simple local rules, and thereby generate - or "grow" - the macroscopic regularity from the bottom up."

J. Epstein (1999) Agent-Based Computational Models And Generative Social Science. *Complexity* 4(5)41.

Types of models

- Mathematical models
  - Cobb-Douglas production function
  - $Y = AL^{\alpha}K^{\beta}$,
    - Y = output, L = labour input, K = capital input
- Scale models
  - Reduced scale
  - Some features simplified
- Analogical models
  - Model is better understood than target
- Ideal-type models
  - Some features are exaggerated
- Model detail
  - Abstract
  - Middle range
  - Facsimile

Bill Phillips' MONIAC at the Reserve Bank museum, Wellington, New Zealand

Abstract models

- Aim: demonstrate some (probably emergent) social process or mechanism
- No corresponding specific empirical case
- Example:

  Models of opinion dynamics

  Evolutionary game theory

- Validation criterion:

  Does it generate macro-level patterns that seem plausible?

- Problem:

  Gap between model and empirical data

Opinion dynamics

- Studies of opinion dynamics
  - How (political) opinions change due to people influencing each other
- Agents have
  - An opinion (-1 to +1)
  - An uncertainty about their opinion (0 to ∞)
  - An opinion segment (opinion ± uncertainty)
- Agents meet randomly and if their opinion segments overlap, their opinions influence each other, by an amount proportional to the difference between the opinions, and inversely proportional to the influencing agent's uncertainty. So uncertain agents influence little, and certain ones influence a lot.

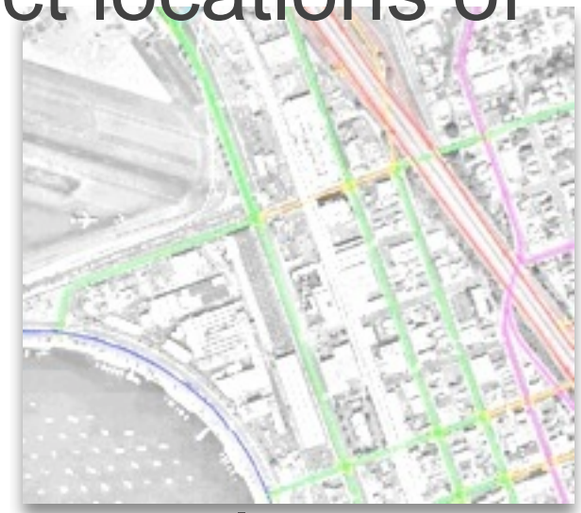
Deffuant model of opinion dynamics

Guillaume Deffuant, Frédéric Amblard, Gérard Weisbuch and Thierry Faure (2002) How can extremism prevail? A study based on the relative agreement interaction model *Journal of Artificial Societies and Social Simulation* vol. 5, no. 4 <http://jasss.soc.surrey.ac.uk/5/4/1.html>

Facsimile models

- Aim: provide an exact reproduction of some target phenomenon
- Often intended to provide predictions
- Example:

  a model of the traffic in a city, used to predict locations of potential jams



- Validation criterion

  does it lead to accurate predictions?

- Problem:

  accurate predictions may be impossible for complex systems; implicit *ceteris paribus* may be untenable

Middle range models

- Aim: understand the generative mechanisms that lead to a particular social phenomenon
- Should be applicable to many specific cases
- Example:

  models of epidemics, innovation networks, utility markets
- Validation criteria:

  qualitative resemblance

  similar dynamics

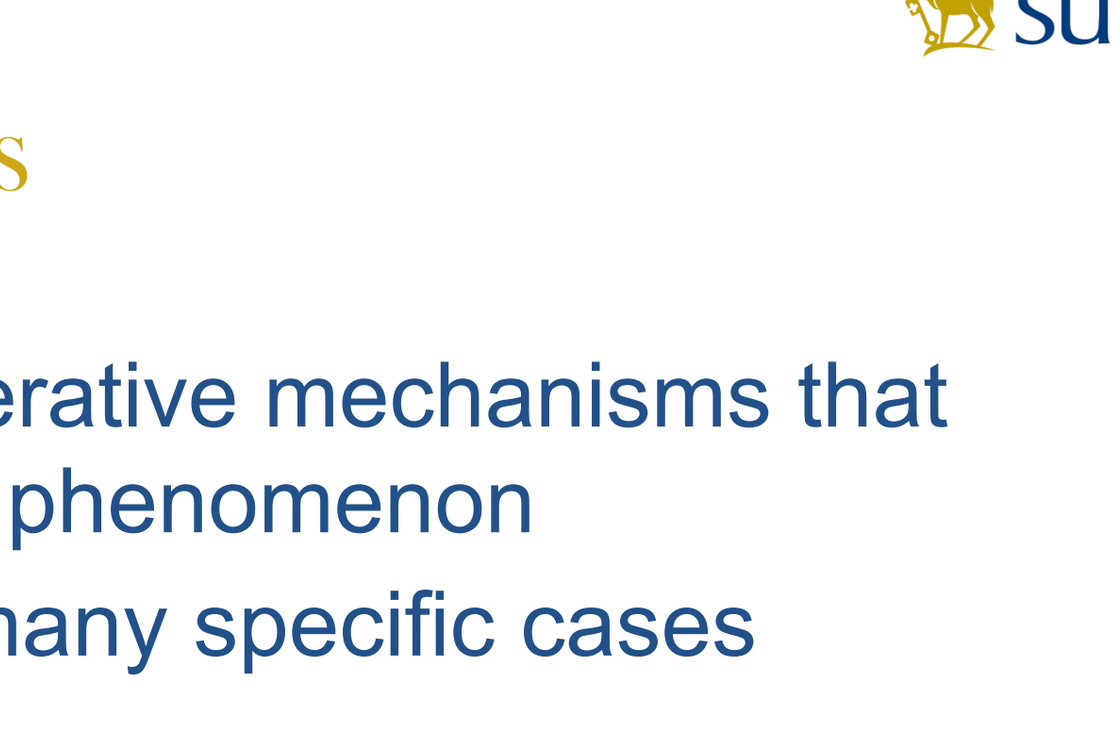


Fig. 6.3-2. The density of infected locations on day 128 of the base case epidemic, when the epidemic is at its peak, for 10 a.m.

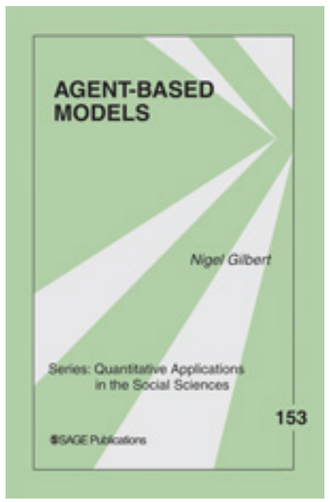
From http://public.lanl.gov/stroud/LACaseStudy5.pdf

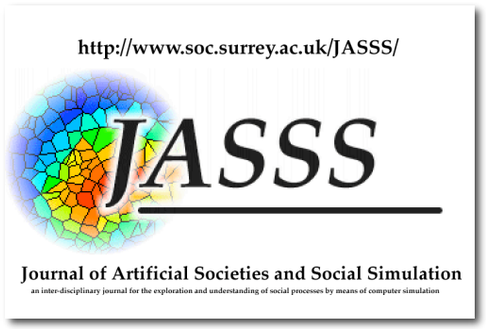
Open issues

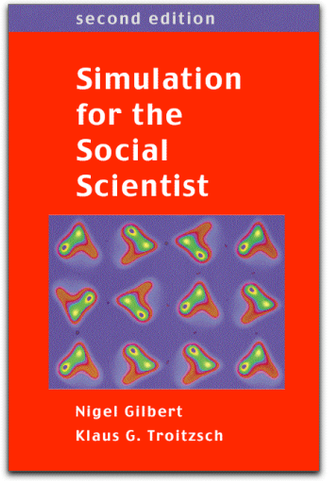
- What, if anything, can we predict accurately?
- What do we do with cognition?
- How do we validate ABM against (longitudinal) data?

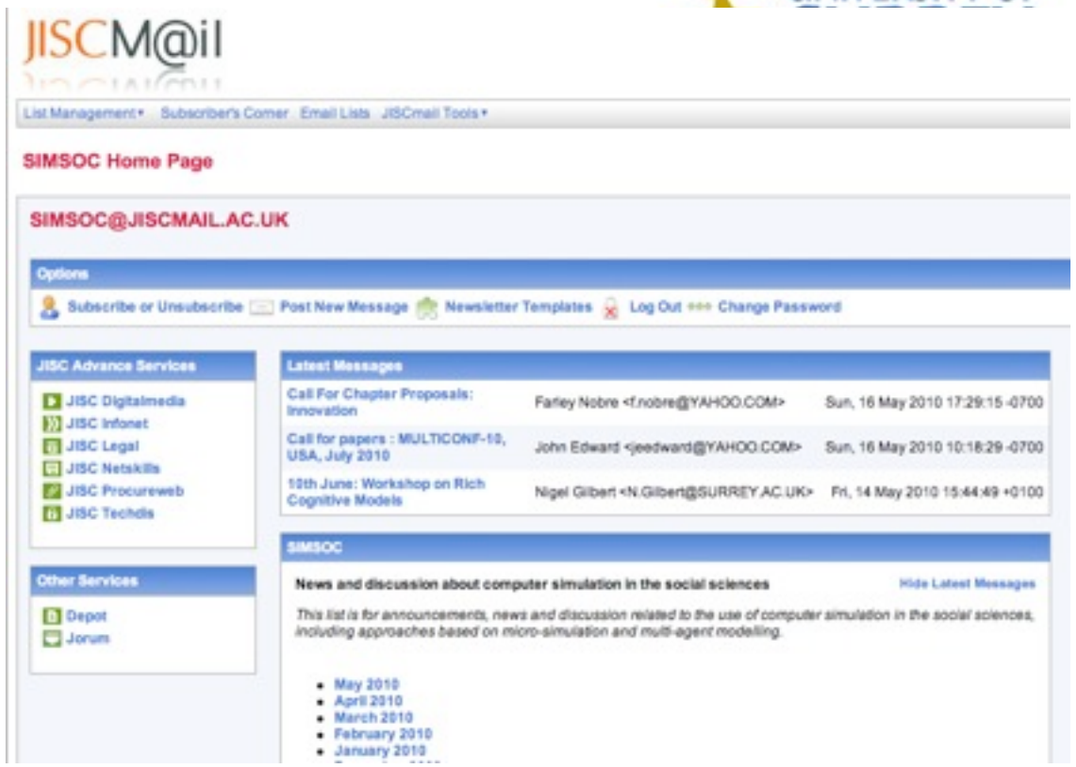
More information

European Social Simulation Association
http://www.essa.eu.org









The National Centre for Research Methods (NCRM) was established in 2004 to provide a focal point for research, training and capacity building activities. These activities are aimed at promoting a step change in the quality and range of methodological skills and techniques used by the UK social science community, and providing support for, and dissemination of, methodological innovation and excellence within the UK.

The three year SIMIAN project started in September 2008 as an NCRM node. It involves a collaboration between the Centre for Research in Social Simulation (CRESS) at the University of Surrey and Dr Edmund Chattoe-Brown at the University of Leicester.

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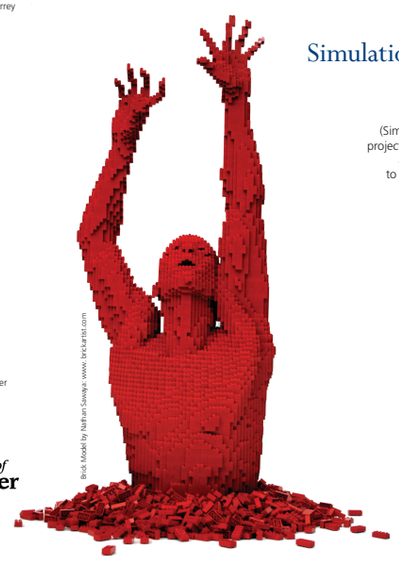
SIMIAN
Simulation Innovation: a Node



Simulation Innovation

The SIMIAN (Simulation Innovation: a Node) project is funded by the Economic and Social Research Council to promote and develop social simulation in the UK

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Thank you

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