A Brief Introduction to Policy Modelling

using agent-based simulation

Session 2

Applying ABS to Policy Issues

Policy Modelling

About Policy Modelling

- Using models to anticipate or understand the impact of policies by governments or firms
- For example:
  - the UK government has a population model that enables them to calculate the cost of welfare and tax policies (if the population does not change/ react)
  - Treasury model of the economy tries to predict future economic growth
- Many of these work by comparing the equilibria of different policy assumptions
- Not a good record of prediction if things change

The Engineering/Rational Expectations approach

1. One makes an 'approximate' model
2. Then different versions representing each policy under consideration
3. Measure the impact predicted for each
4. Compare them and choose the best policy

Has **big** disadvantages:

- Where social reaction/interaction occurs, models include ***very*** strong assumptions
- Hence, do not have a good predictive track record
- Then policy actors are faced with a dilemma: trust a model which they do not understand ***or*** go with their own instincts/knowledge (so they only trust the model if it confirms their own guess)

An alternative, "*risk-analysis*", approach

- Do not pretend to predict when situation is complex
- Make more descriptive models with more alternatives, but less strong assumptions
- Use models to understand some of the processes and outcomes that can occur with these assumptions – exploring possible outcomes
- Produce a risk-analysis of what could go wrong (or right) in the complex situation
- Produce simple indicators/visualisations of data to indicate ***when*** these kinds of situation are occurring
- It will ***not*** get ***all*** the possibilities, but a policy maker is better informed and can implement monitoring to know when these might be starting to occur

Agent-based Policy Models

- Are more particular to each situation
- Use less abstract assumptions that are amenable to testing and research
- Can be as complex or as simple as required
- Assumptions can be based on domain knowledge or stakeholder input
- Will still have assumptions based on guesses but these can be varied to see their effect
- But are very hungry for data and evidence
- They have a huge space of variations
- And are time-consuming to make & test

Examples

For the rest of this session, we will look at some illustrations of agent-based policy models. These are simplified versions of full policy models, for you to play with.

These are:

- A model of infection in a population
- A model of the rental housing market

Followed by a Q&A session and some indications of what to do next if you want to learn more

An Example:
A Simple Infection Model

The SIR model of infection

- Now the classic model of disease spread
- Divides the population into three groups: the susceptible (**S**) infected (**I**) and recovered (**R**).
- The **S** can become **I** (after contact with another I), the **I** can become **R** (or die), the **R** have immunity, but eventually become **S** again.
- Fixed probabilities of each transformation happening (given contact condition for **S**→**I**)
- In the original model individuals were randomly mixed together (no social network) which made it possible to solve the equations

A networked version

- Instead of dealing with equations relating to a global distribution we have individual agents connected by a (fixed) network
- There are **S**usceptible agents (grey), **I**nfected (red) and **R**ecovering (violet).
- At the start the network is generated (depending on settings)

Then for each time click:

- Each **S** has a probability (prob-infect) of being changed to an **I** for each **I** it is linked to
- Each **I** has a probability (prob-recover) of being changed to an **R**
- Each **R** has a probability (prob-susceptible) of being changed back to an **S** again

Simple model of infection

- Load and run the "infection.nlogo" model

Normal controls plus 'infect'

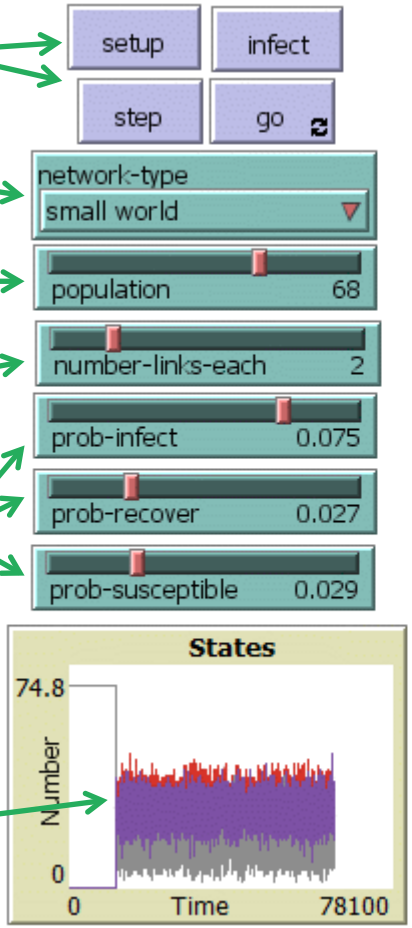
Kind of network

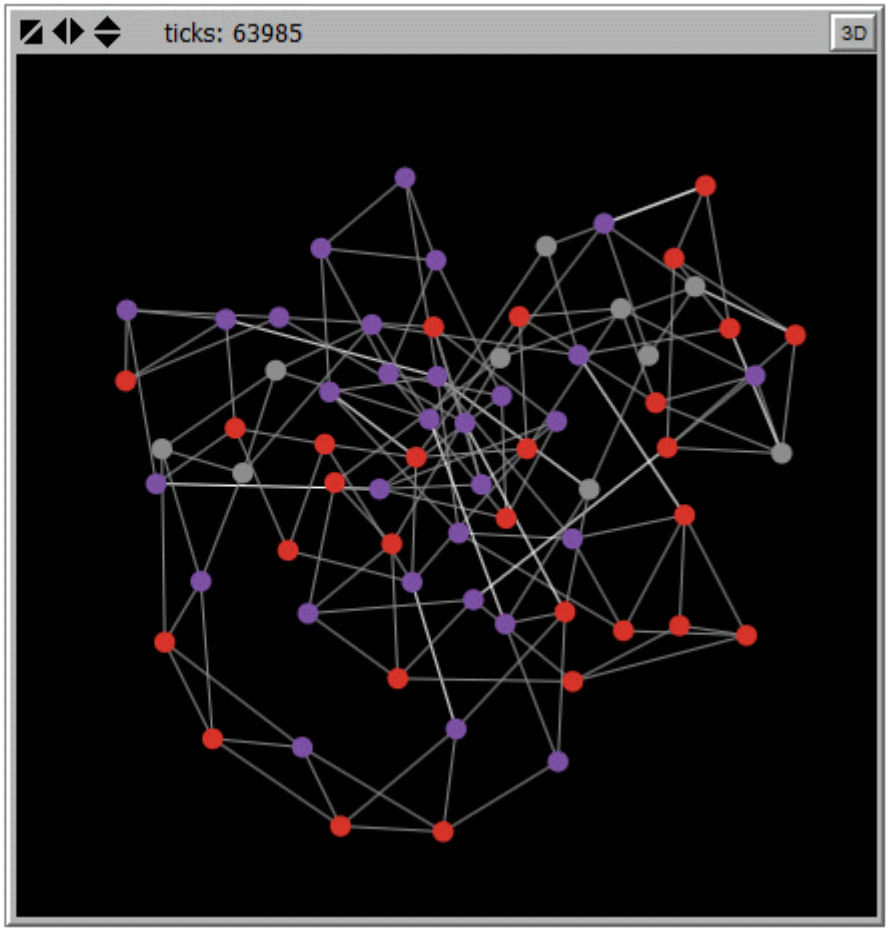
Size of network

Density of links

The 3 probabilities of SIR model

Graph of total number of Infected, Recovering and Susceptible





Manchester Metropolitan University

Key part of code

```
to go
  ;; things that happen to susceptible
  ask turtles with [color = grey] [
    repeat count link-neighbors with [color = red] [
      if with-probability prob-infect [
        set color red
      ]
    ]
  ]

  ;; things that happen to infected
  ask turtles with [color = red] [
    if with-probability prob-recover [
      set color violet
    ]
  ]

  ;; things that happen to recovered (but immune)
  ask turtles with [color = violet] [
    if with-probability prob-susceptible [
      set color grey
    ]
  ]

  tick ;; this progresses the tick counter by one
end
```

For each **grey**: for each **red** neighbour, change to **red** with probability

For each **red**: change to **violet** with probability

For each **violet**: change to **grey** with probability

Things to try

1. Set the three SIR probabilities
2. Pick a network type
3. Then for different "number-links-each":
   a. Press 'setup' then 'go'
   b. Click 'infect' as it is running and see if the infection takes off (an epidemic) or dies away quickly
   c. repeat to make sure it was not a fluke
4. Note the critical "number-links-each" threshold for each network type

- What kinds of network are more susceptible to epidemics?
- Once an epidemic is going, how many agents do you have to inoculate to stop it?
- For different SIR probabilities are different kinds of network more susceptible to epidemics?

This simple model

- Predicts infection rates well for some kinds of disease and less well for others
- For some aggregate equations are fine, for others you need this kind of model

Obvious extensions include:

- Different kinds of agent (child, adult, care worker, etc.)
- More realistic networks (cities, towns etc.)
- Moving agents (commuting, holidays etc.)
- Meeting places (work, schools, planes, trains etc.)
- Changing networks in response to an epidemic

These kinds of model were used in the 'foot and mouth' outbreak, but…

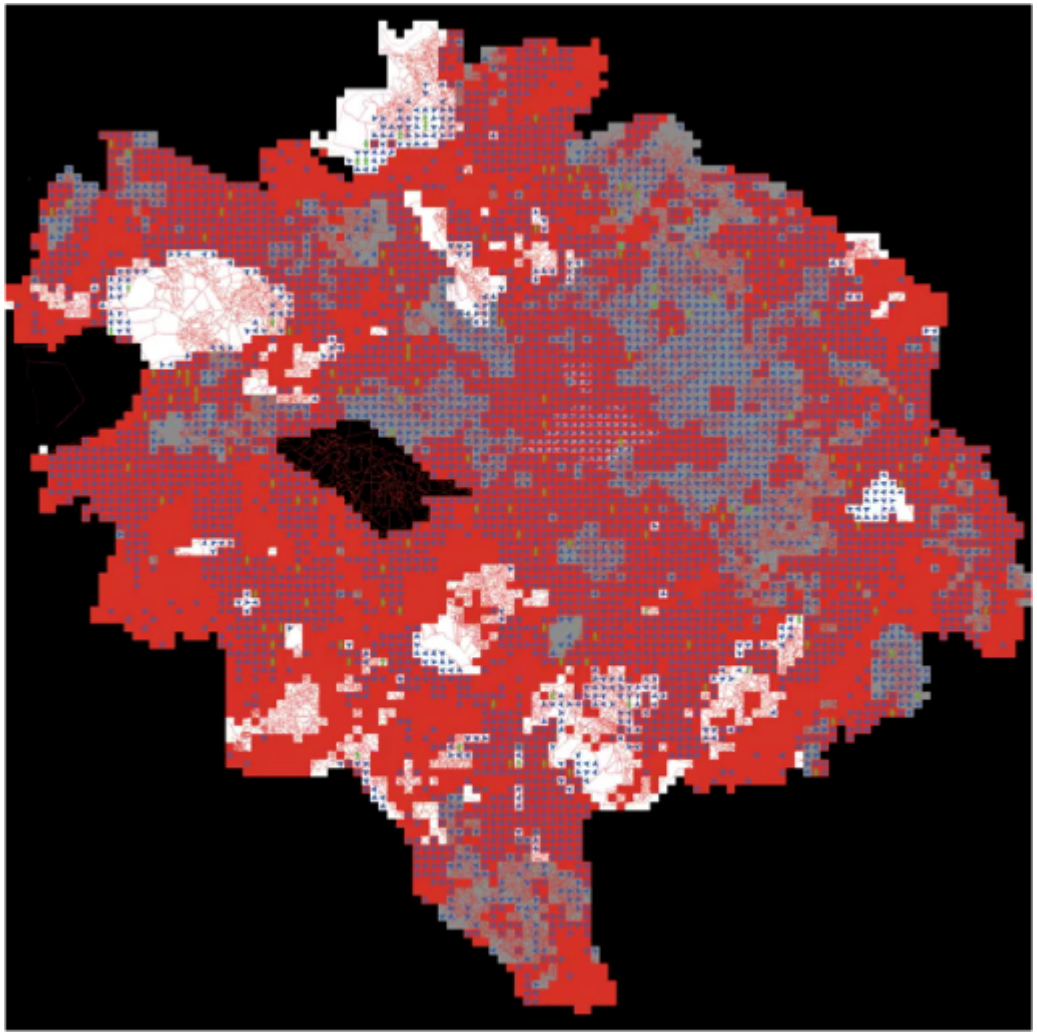
- Initially, ministers rejected the models because they were appalled at the simplifying assumptions
- Later, modellers and policy makers came back together and collaborated (modellers adapted models to make them more realistic, ministers learned what models could and could not tell them)
- But ministers were still very cautious, resulting in a huge 'over-kill' in response
- The caveats modellers appended to their conclusions were often removed as these were passed 'up the chain', leading to the modellers becoming increasingly cautious in their conclusions

An Example: *A Model of the Rental Housing Market*

The model

- By *Stefano Picascia*, a PhD student of mine, now at Sienna University, Italy
- Is an agent-based simulation that represents both tenants and developers co-adapting
- Is geographically based with tenants making decisions as where to move to based on location as well as quality of housing and price
- Developers put in captial to build/rennovate housing for tenants
- Rents are determined by the quality and prices of surrounding housing

The Manchester Case

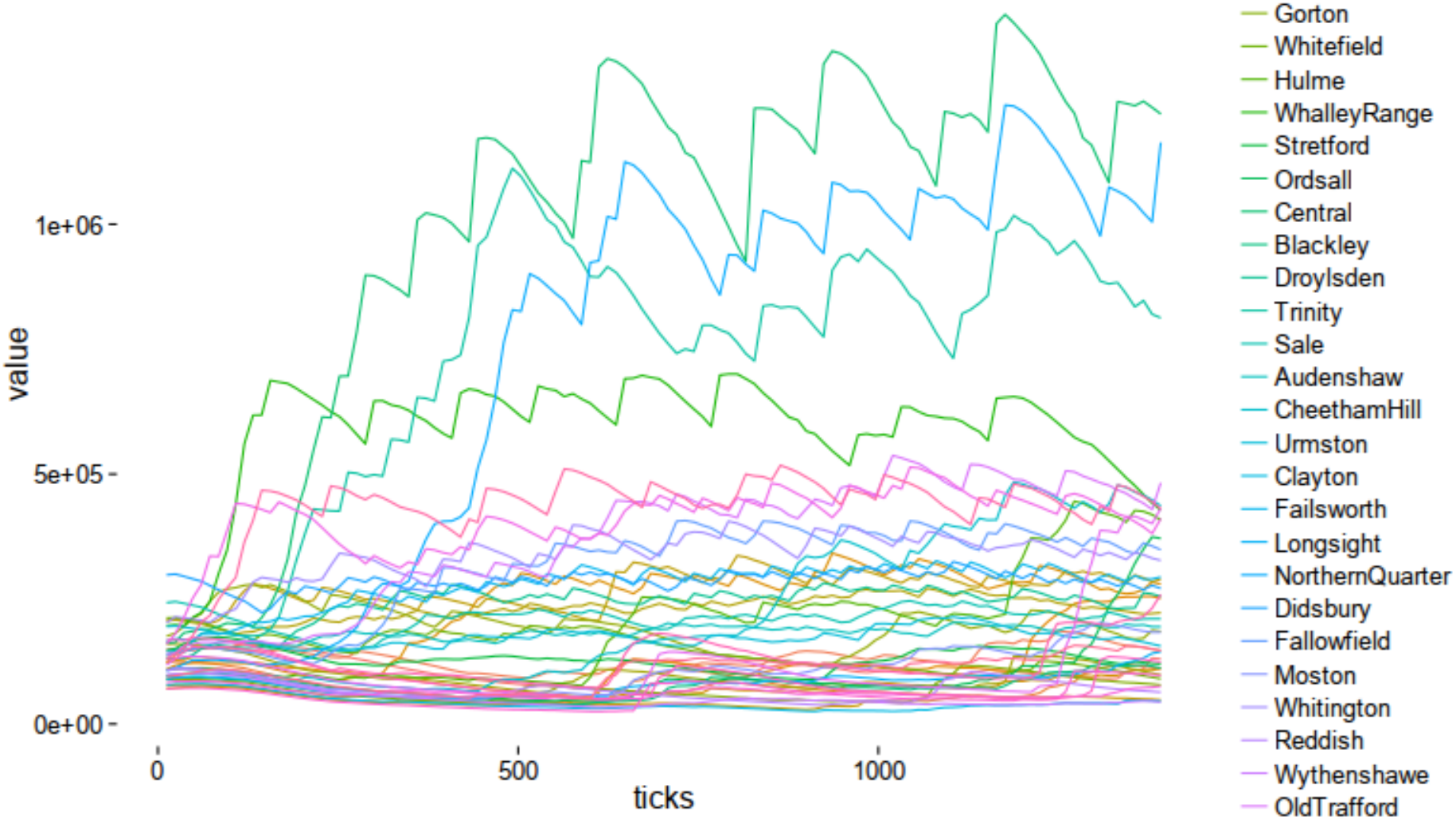


- Waves of price changes can spread
- Can have different outcomes each time it is run
- Has also been applied to London and Beirut

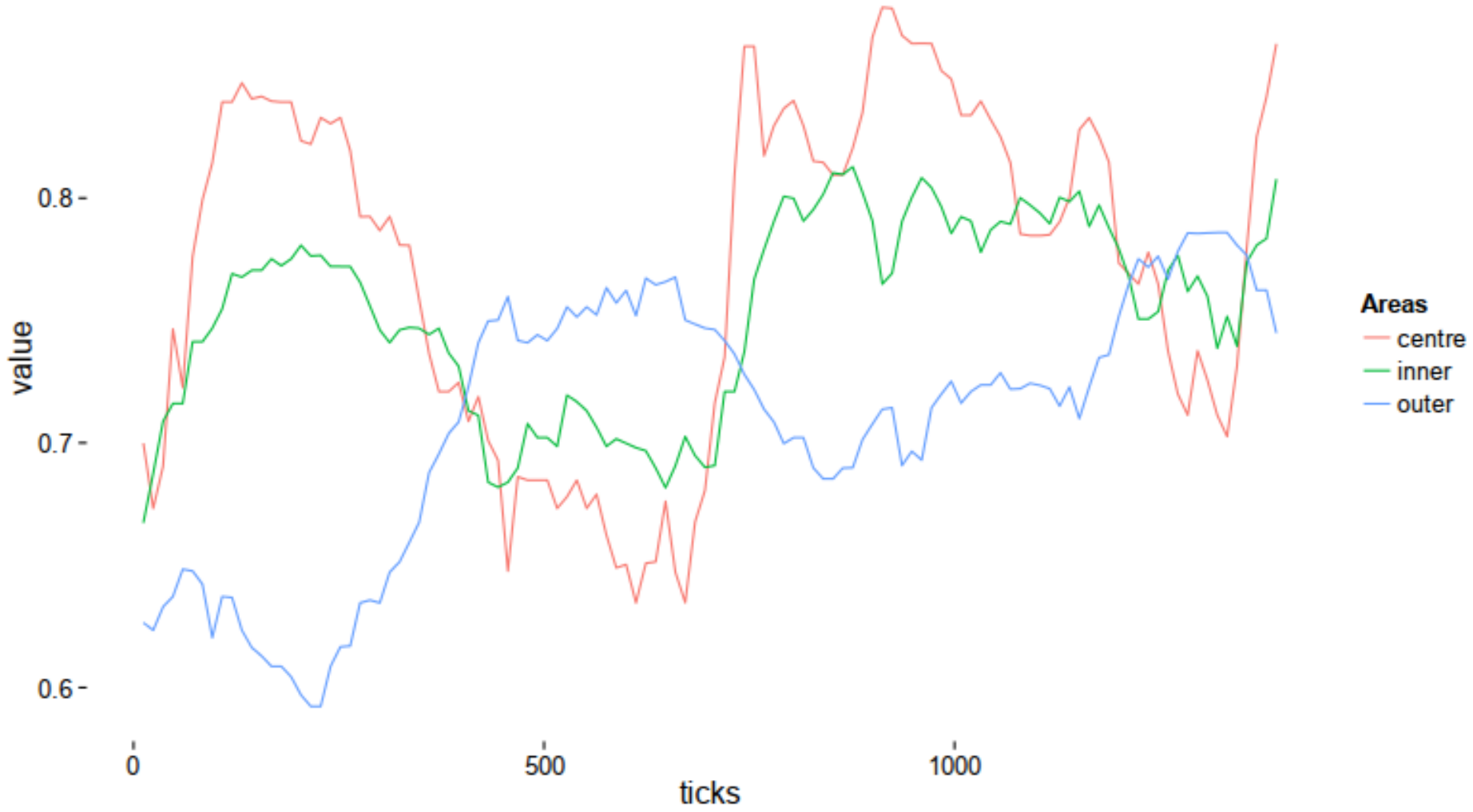
Video of model running is at:
http://www.youtube.com/watch?v=PtYTtkPrACM

Manchester Metropolitan University

Average prices in a run



Different Sectors of the City in a run



What it does and does not tell us

In the model (which is the private rental sector only):

- That change is fundamentally internally driven as well as due to outside events
- Price oscillations are endemic to the system
- That some regions of cities will be stuck as low quality housing for long periods of time
- The very high price regions stay that way
- That under certain conditions sudden ‘gentrification’ may occur to some degree
- For poorer districts decline is gradual and continual between any such periods

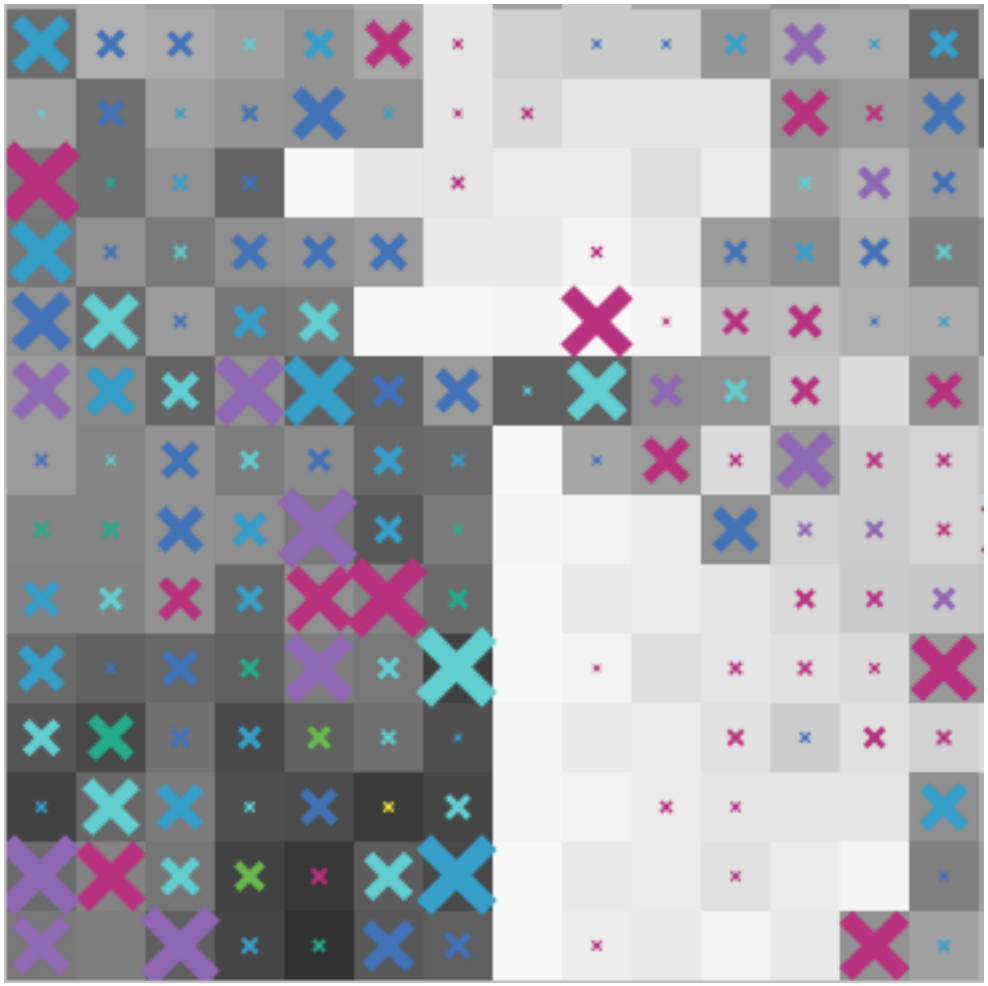
Manchester Metropolitan University

A cut down version

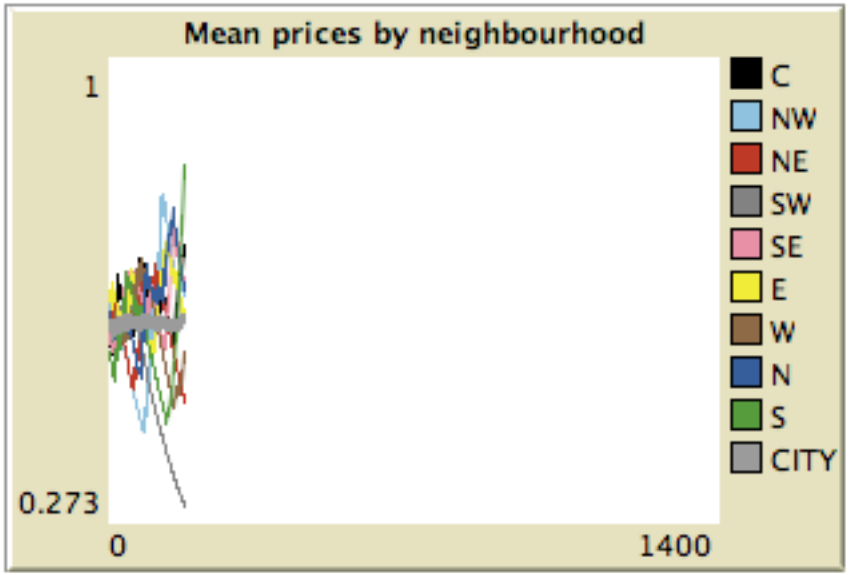
- Download and run the model "housing.nlogo"
- This is essentially the same model as the one just described (it has the same processes), but
  - at a much smaller scale,
  - on a square 2D grid
  - randomly initialised
  - some of the many options and parameters hidden

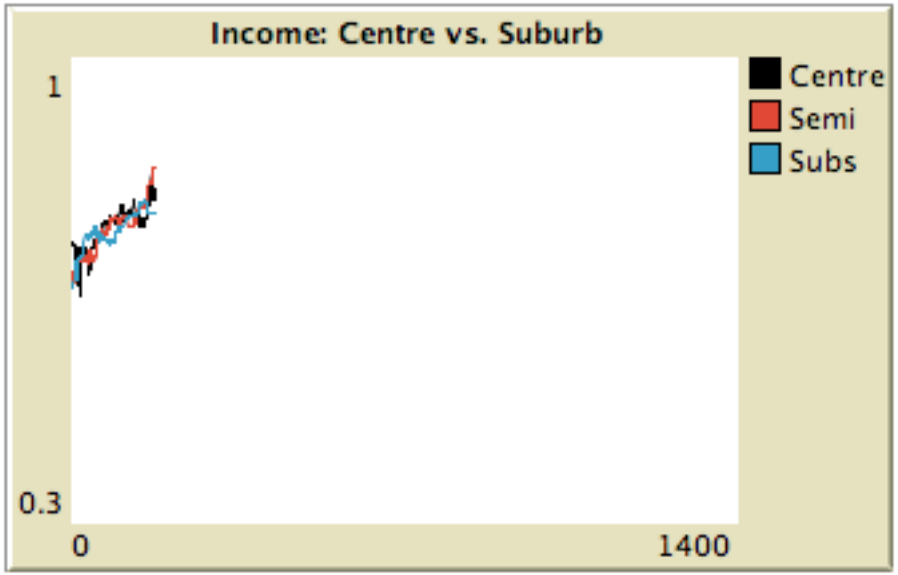
The World View

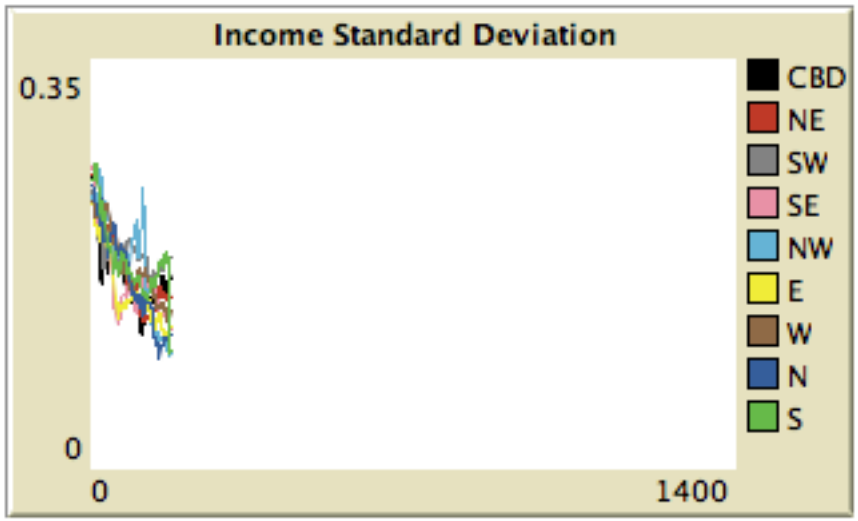
- ***Patch shade*** indicates rent – white is expensive down to black, which are slums
- Crosses are renters – ***size*** indicates how long they have been there; ***colour*** their income (red/orange poor up to violet/ magenta rich)

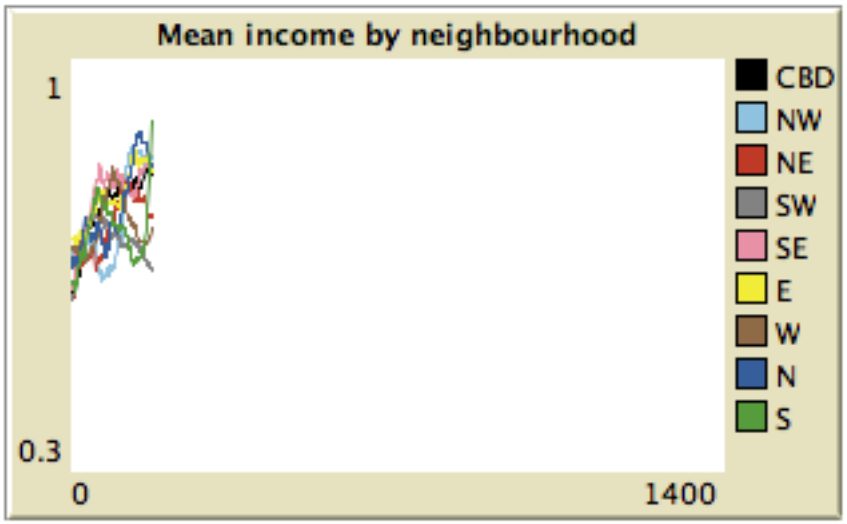


Key Graphs – Rents and Incomes



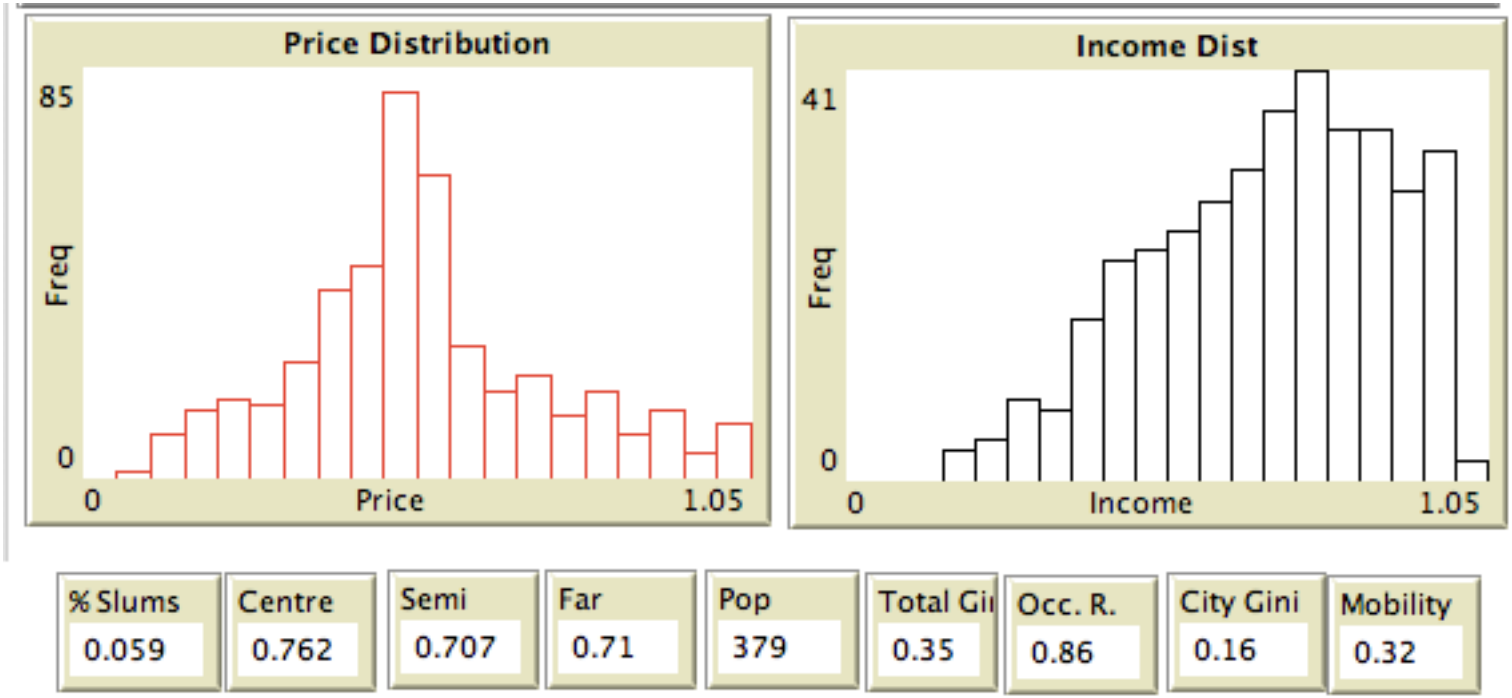






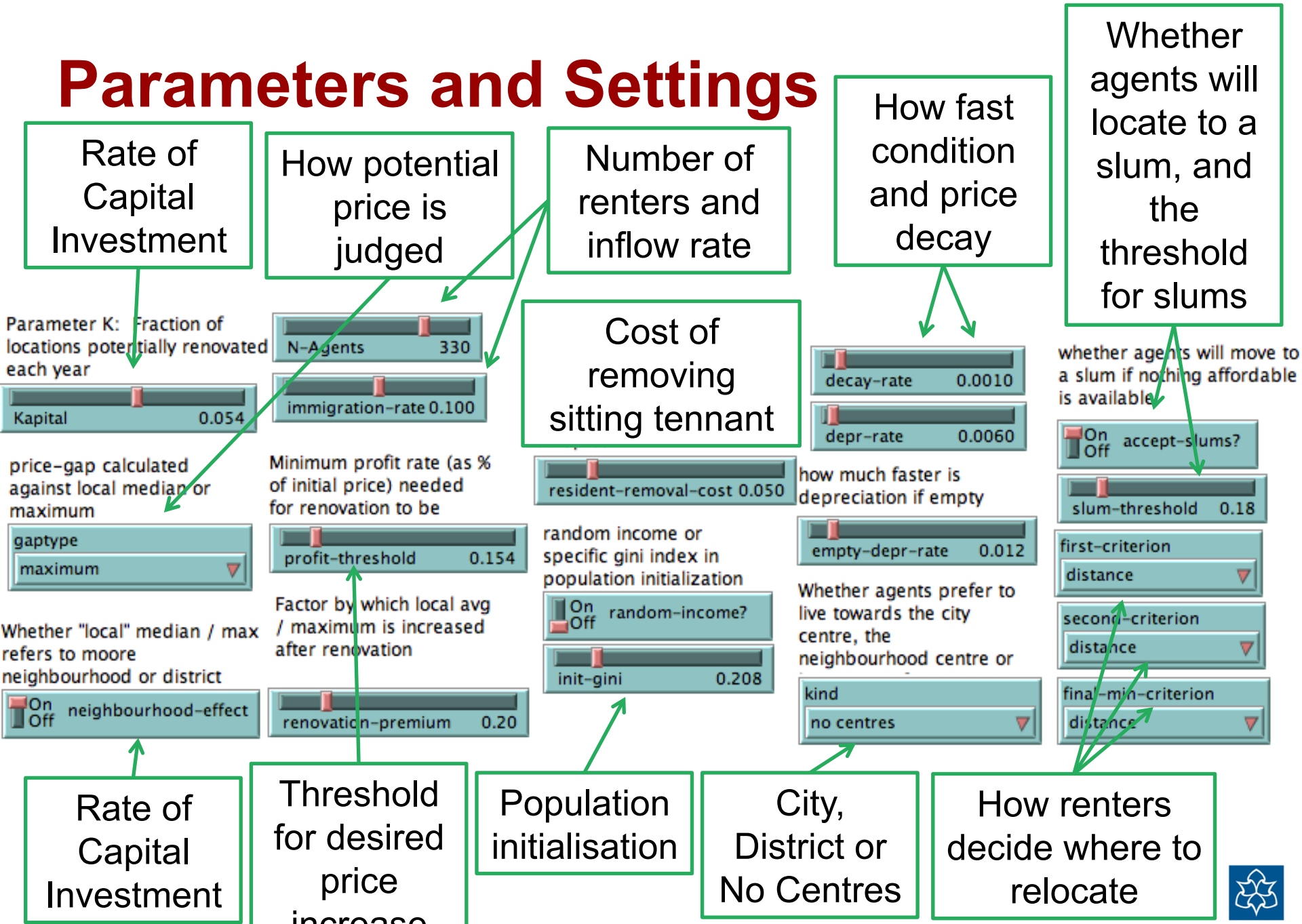
Manchester Metropolitan University

Distributions and Statistics



- Rent and Income distributions
- Various statistics (if Do-Stats? switch is on)
  – 'Gini' is an index of inequality: 0 all the same, 1 one individual has all

Parameters and Settings



Things to explore...

Under what settings do you get:

- Only one district with good housing and the rest permanent slums?
- Cycles of prices going up and down within a district?
- The movement of areas of better housing across the area?
- Sudden ‘gentrification’ – prices increasing in a district from a stable low to a higher level?

Some Observations

- Its hard to get one's head around such complicated models
- Multiple visualisations of the outcomes are very helpful to understanding them
- Although they have many parameters and settings these have meaning in terms of what they refer to – they are not free parameters and could be measured
- They can be more suggestive than other kinds – beyond the level of their validation!

Modelling within the UK government

- Is becoming increasingly professionalised and is now among the best in the world
- The debacle over a train franchise lead to the development and adoption of sensible new standards for all such modelling (the 'Aqua Book' – publically available)
- Modelling does take a long time to develop, iterating development and testing phases – models that just 'feel' plausible are not enough
- But there is still huge potential for huge long term benefits (e.g. last goverment's innefective support for first time buyers costing over a £1B)
- They are cautiously considering agent-based modelling, but still have largely the 'test & predict' model of policy development

If you have finished…

- … try playing with some of the other simulations
- Goto http://cfpm.org/eaepe/
- And read the document: "Other models to play with.pdf"
- And follow its instructions
- Each time: read the "Info Tab", play with the simulation, look at the code (but only expect to understand small bits of the code as yet)

If you want to learn more…

…look at http://cfpm.org/simulationcourse …
in particular:

1. Slides and examples of the 8 sessions of the 2-day course:
   Course Outline >> Day 1 >> Session 1 etc.
2. Get and read some of the books:
   General Resources >> Books
3. Download and play with lots of examples:
   General Resources >> Collections of Netlogo models
4. Read the journals, join the forums listed:
   General Resources >> Web Social Simulation Resources

Q&A Session

The End

Housing and voting models developed funded by the EPSRC, grant number EP/H02171X

Manchester Metropolitan University

SCID

THE SOCIAL COMPLEXITY OF IMMIGRATION AND DIVERSITY

EPSRC

Engineering and Physical Sciences Research Council

DiDIY

DIGITAL DO IT YOURSELF

C21

I2I

Insight to Intervention

HORIZON 2020

MANCHESTER CITY COUNCIL

PEERE

The Centre for Policy Modelling: http://cfpm.org

KNOWeSCAPE

2-Day Introduction to ABM http://cfpm.org/simulationcourse

These slides and examples available at: http://cfpm.org/eaepe