

# Practical examples that people have paid money for

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## Some ABM clients

- Financial Services Authority
- Department of Health
- South West Regional Health Authority
- British Telecom
- Svenska Handelsbanken
- Advertising Association
- Water company consortium

# Why do people want them?

- **To answer specific question(s) they may have e.g.**
- Why has our market/company evolved the way it has
- What happens if.....? *This is the single most frequent use*
- How do we persuade the regulator that.....?
- They are all practical questions to which practical answers are needed
- There are usually time (and resource) constraints

# The process

- To varying degrees, domain specific knowledge from the client needs to be extracted
- The individuals who you deal with usually face serious time constraints – they are very busy
- This points to high level, parsimonious models
- Need to specify the agents, how/what they decide, who they are connected to
- Plausibility of the results to the client is a key part of validating the model – ideally, you want most results to be expected plus a few which are not!
- This is not to forget the need for scientific merit – the model may often face external scrutiny

## ABMs and policy modelling: elective surgery in the National Health Service

- Carried out for UK Department of Health: client actively involved
- Elective surgery in the NHS was essentially centrally planned: you have your operation in the hospital nearest to you
- What happens if consumers can choose where to go?
- Decision rules for consumers and providers
- Agents are heterogeneous, operate with imperfect information, are often myopic, and do not necessarily maximise

# Who does what?

- There are consumers and producers (hospitals)
- There is the NHS, but this simply allocates an amount of money for each operation, it has no other role
- Consumers decide which hospital to go to for their operation (or their doctor might, we do not distinguish the two)
- Hospitals decide whether to invest money in effort, quality and capacity
- There are potential new entrants who decide whether to enter the market
- There are no network effects in this model

# Consumers (1)

- How do we introduce the complex range of factors relating to the ability and propensity of different social groups both to gather information and to exercise choice based on that information ?
- The model has spatial structure, but every consumer in a given area is assumed to live at the same location –we do no attempt to measure actual locations
- We assume there is inertia, and poorer areas will be more likely just to choose the local hospital regardless of other factors than richer ones
- So consumers in a given area choose their local hospital with probability  $\sigma(r)$ , drawn from a uniform on  $[0,1]$
- This parameter is common to all consumers in a given area.
- If they do not choose the local one automatically, they examine their utility functions – these may still lead the local one to be selected

## Consumers (2)

- Consumer utility depends upon quality of hospital, wait time and distance to hospital (all scaled in  $[0,1]$ )
- They perceive the latter two accurately, but quality with considerable error (though correct on average)
- 4 types of consumers identified by Dept of Health stated preference research, with different (and fixed) weights on the 3 factors
- Approximately 70 per cent give a weight of 0.6 to distance, 10 per cent give weight of 0.8 to wait time, only 10 per cent give 0.8 to quality
- There are thresholds for each beyond which no-one will choose the hospital regardless of the other variables, but these are lax



# Producers (1)

- Hospitals differ in quality, effort, efficiency, the number of consumers they treat, and capacity
- Efficiency is the structural efficiency of the hospital and determines fixed costs. It is allocated by a random draw
- Effort is under the control of the hospital: how hard they try to keep costs down
- They receive a fixed amount of money for each consumer treated (set equal to 1)

## Producers (2)

- Department of Health specified a general cost function
- One part is a complicated expression involving quality, effort and the number of operations. It increases with each of these three
- The other part is the capacity of the hospital multiplied by a random number – this is a measure of the efficiency of the hospital
- The model runs for 52 steps, then the hospitals get the chance to change quality,effort,capacity. Another 52 steps, then another etc

## Producers (3)

- **'Easy Life'**: try to minimise effort subject to the constraint to break even. They pay little attention to market conditions
- If they make a profit in any given year, in the first instance they simply slacken off, and their effort is reduced
- Effort is reduced to the level at which they predict that they will not make a profit but will break even in the next year
- They predict the number of consumers using simple extrapolation based on the change in the year just ended
- They adjust capacity so that it will be equal to this
- If they have made a loss, they will increase effort until they predict break even. But if effort reaches its maximum and they are still predicting a loss, they reduce quality

## Producers (4)

- **Not for Profit:** maximise  $N(op) * (1-e) * q$
- They seek to maximise the number of customers they serve and their quality, and reduce effort
- They make a projection of  $N(op)$  as above and invest in capacity to provide for this number
- They choose  $q$  and  $e$  to maximise their objective function subject to their need to break even
- If they make a loss, they target to make a profit to offset this loss

## Producers (5)

- All initial hospitals are one of these two types, but **profit maximisers** can enter
- They always set effort = 1 to minimise costs
- they know the quality and capacity of other hospitals now, but not the decisions these have taken about the future
- If a hospital fails, a profit maximiser is deemed to enter at the same location
- A profit maximiser can also enter to compete with an existing hospital at a given location

## Producers (6)

- They set quality above the level of their location and the hospitals either side of this location
- Unless they can make at least  $p$  [5 in the solutions below] per cent profit they do not enter (unless deemed to do so)
- They set capacity to maximise profit given this quality decision
- after one year, if they make a loss or insufficient profit they cut capacity

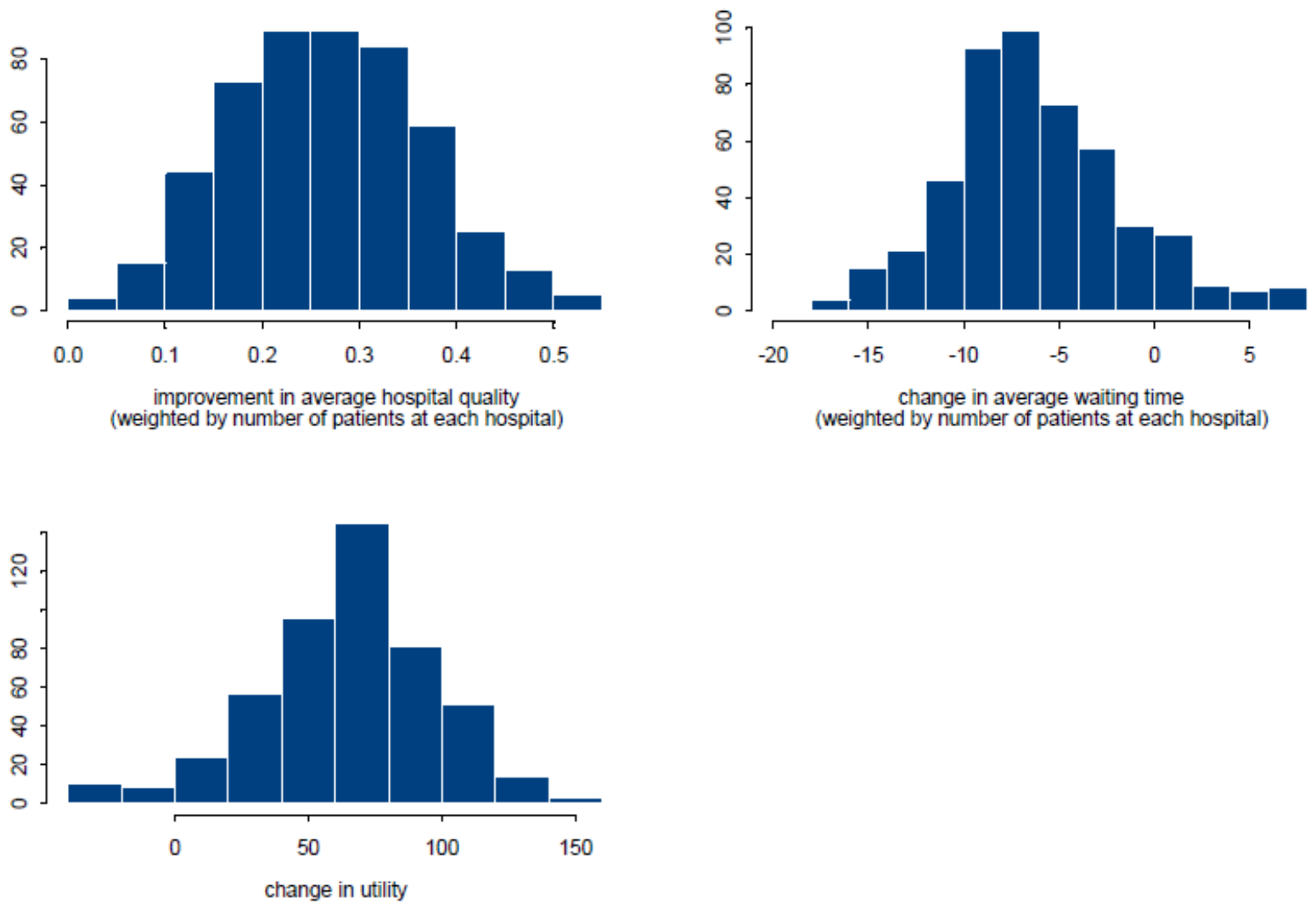
## Starting off!

- Profits and losses are cumulated from one period to the next. A hospital is deemed to exit the market for the particular operation if it incurs a cumulative loss of  $L$  per cent of total cost in any given year [8 in the solutions below]
- The initial quality of the Easy Life is set at 0.225 and of the Not for Profits at 0.5
- Initial wait time is 19 weeks
- 5 Easy Life, 5 Not for Profit
- 500 solutions, over 10 years

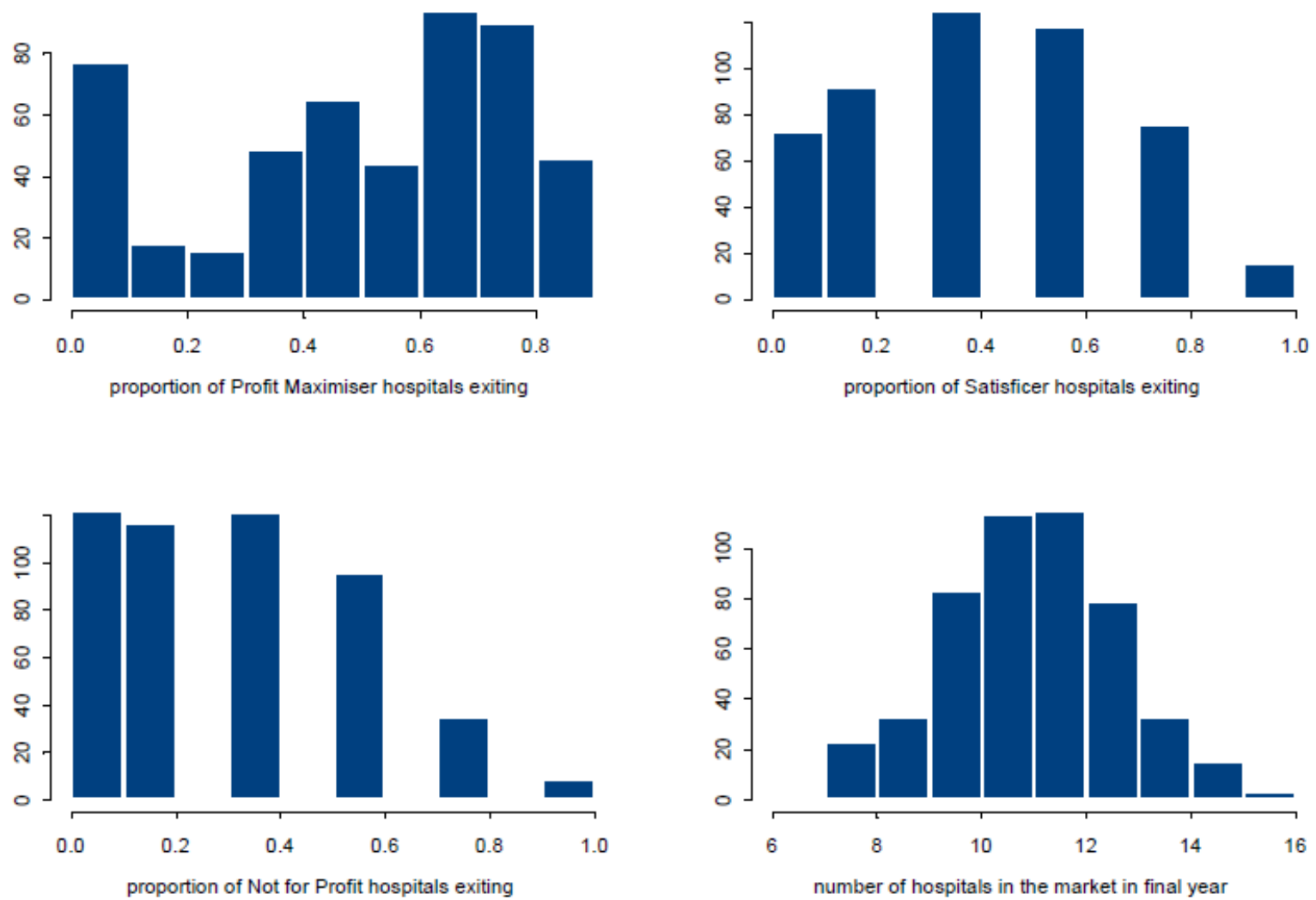
# Summary of results

- Agents are myopic, use simple forecasting rules, exhibit inertia, have imperfect information, some producers are captured by producer interests in their motivations
- **But** in general:
  - average quality improves
  - - average wait time falls
  - - consumer utility increases
- averages are the appropriate weighted average by number of consumers





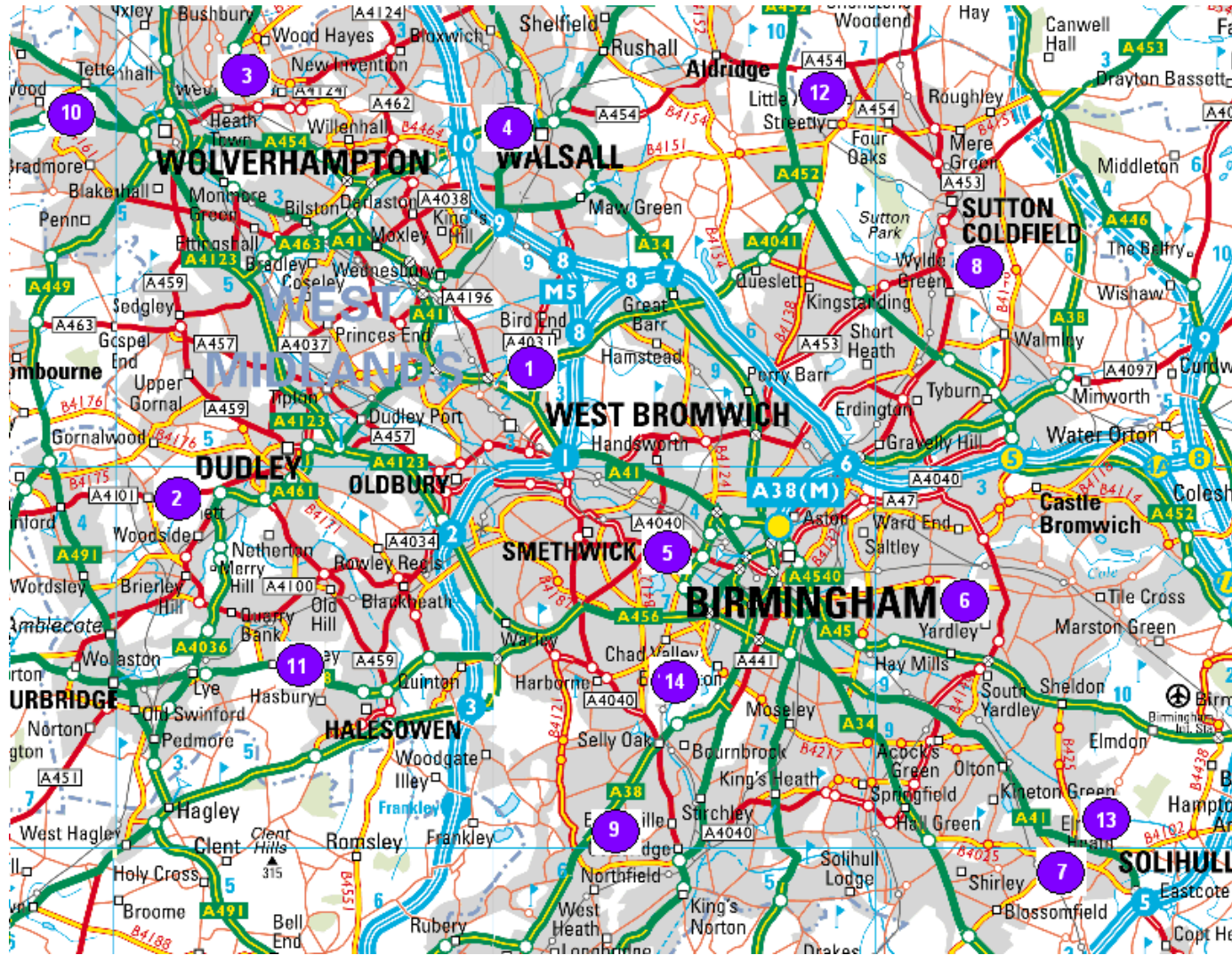
**Figure 1** *Changes in average quality, average waiting times and total consumer utility. Summary of results from 500 separate solutions of the base model, at year 10*



**Figure 2** *Proportions of Hospitals Exiting and Number of Hospitals in the market after 10 years*

## Further analysis

- Interrogate the results statistically to find out why they happen (e.g. change in quality positively related to number of profit maximisers, negatively to the final number of hospitals)
- Check sensitivity to varying tariff, exit rule, profit threshold for maximisers, 'inertia' parameter [ $\sigma(r)$ ], increase accuracy of quality perception, vary weights on consumer utility functions
- Calibrated it to actual data on 13 hospitals in the Birmingham area on elective hip replacement and had the results validated by presenting them to local decision makers



## Hospitals with low probability of exit

- Royal Orthopaedic 9 per cent
- Walsall Manor 15
- Sandwell General 17