Networks and economic theory
INFER, Munster, September 2010

Paul Ormerod

Volterra Consulting, London; Dept of Anthropology, University of Durham; Extreme Events in Human Behaviour Programme, IIASA, Austria

Overview

- Why might we be interested in networks?
- How might networks fit into economic analysis?
- Some examples

The limits to the standard model (1)

- **Vernon Smith**: 'I urge students to read narrowly within economics, but widely in science. Within economics there is essentially only one model to be adapted to every application: optimization subject to constraints due to resource limitations, institutional rules and /or the behaviour of others, as in Cournot-Nash equilibria. The economic literature is not the best place to find new inspiration beyond these traditional technical methods of modelling'
- The standard model has probably already been applied almost anywhere it might be useful
- **Friedrich Hayek**: ' An economist who is only an economist cannot be a good economist'

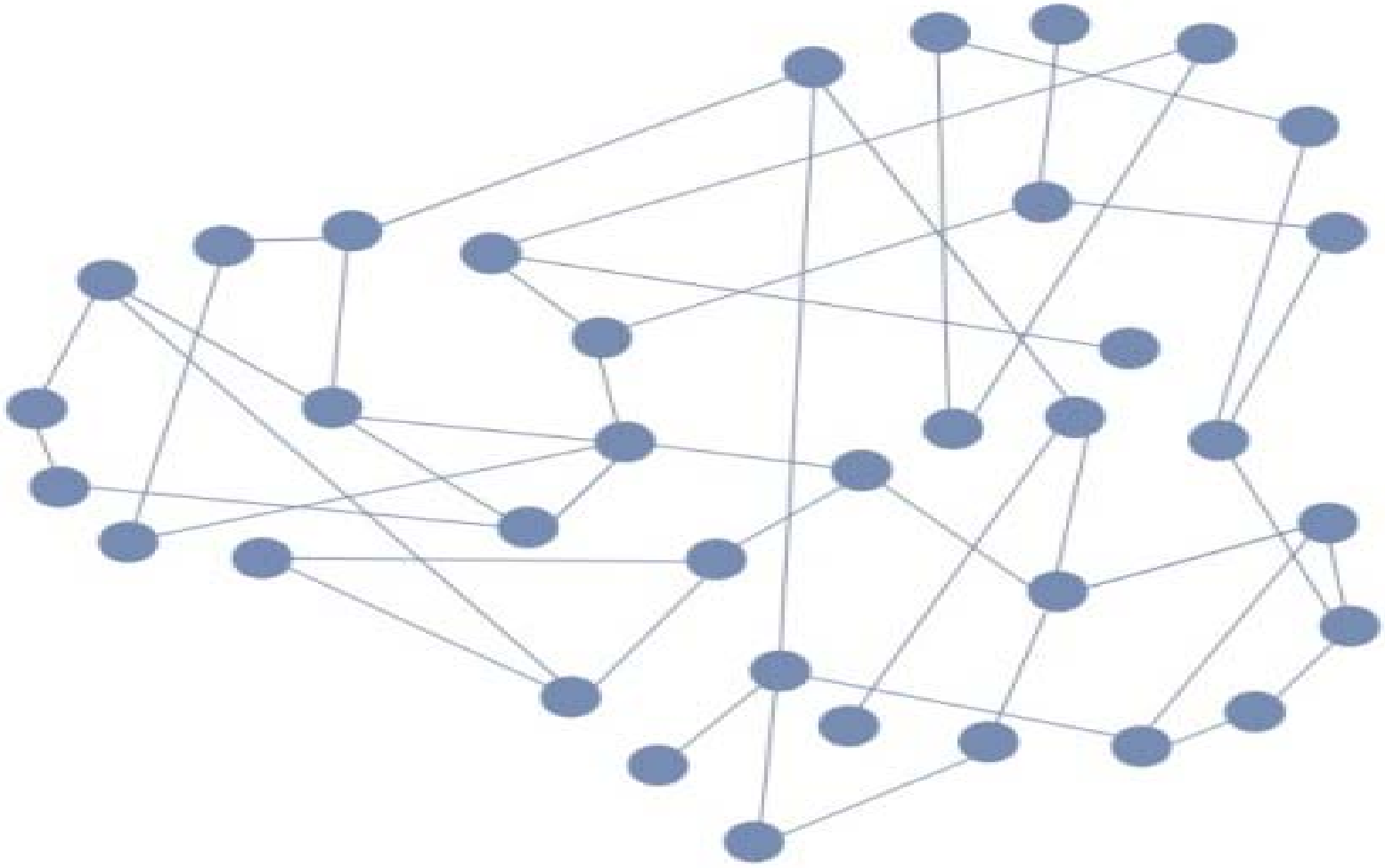
The limits to the standard model (2)

- **R**ational **A**gent **R**ational **E**xpectations –RARE
- Why did the 2008/09 crisis happen according to mainstream theory?
- Can rational expectations ever be rejected for a 'true believer'?
- Individuals act in isolation – even under bounded rationality
- Much of the discipline of psychology rejects the assumption of rationality empirically
- Much of the discipline of sociology rejects the assumption that individuals act purely in isolation, they are part of society

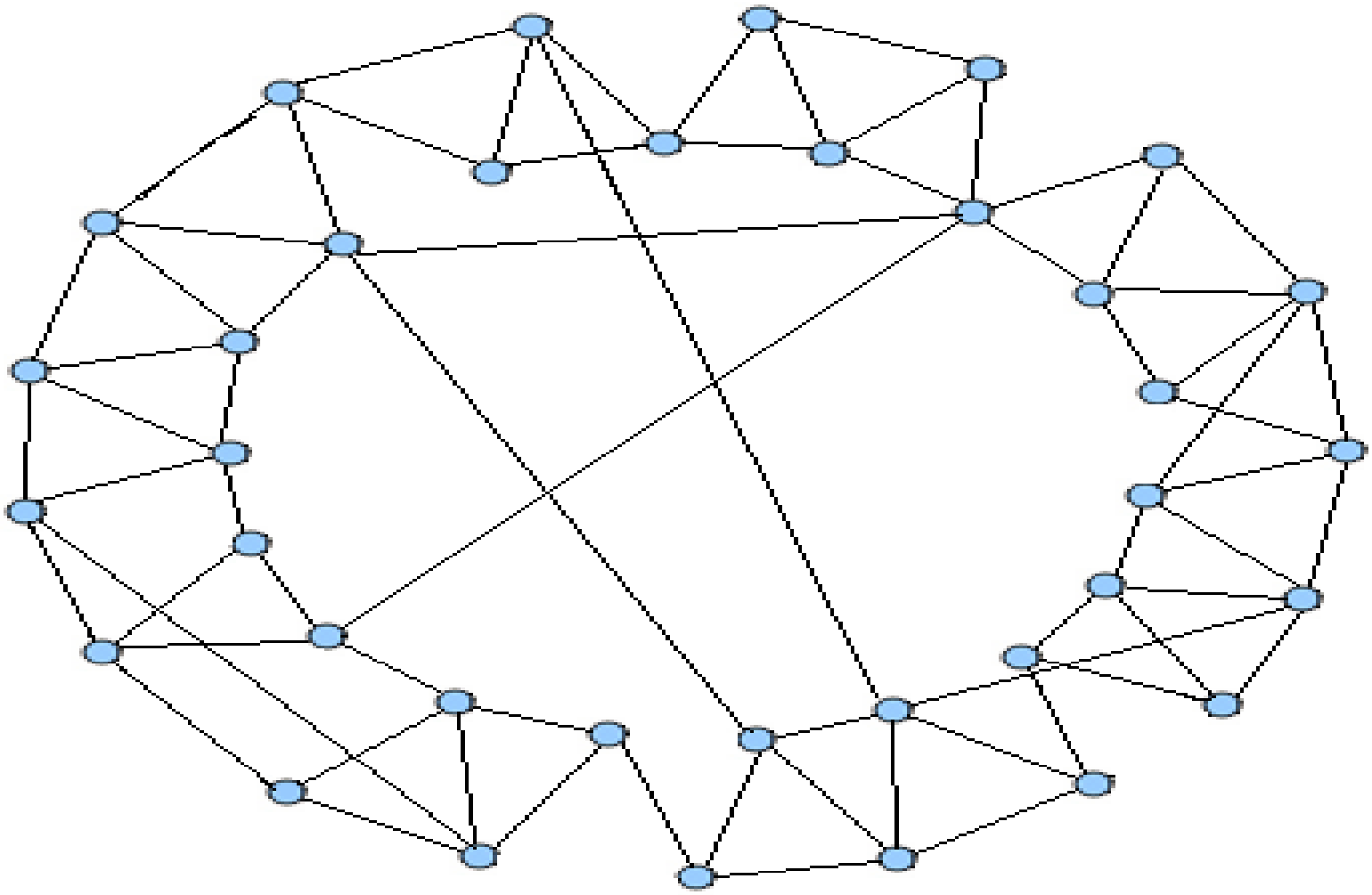
Networks (1)

- One way of thinking about networks is that they make explicit the agents from which/to which any given agent receives/sends information
- In this sense they help formalise bounded rationality
- In empirical studies of social and economic issues, several 'stylised' types have been identified: fully connected; random; small world; scale free
- They differ in the ease with which information is transmitted – percolated – across the system
- MEJ Newman, *Networks: An Introduction,* Oxford University press, 2010

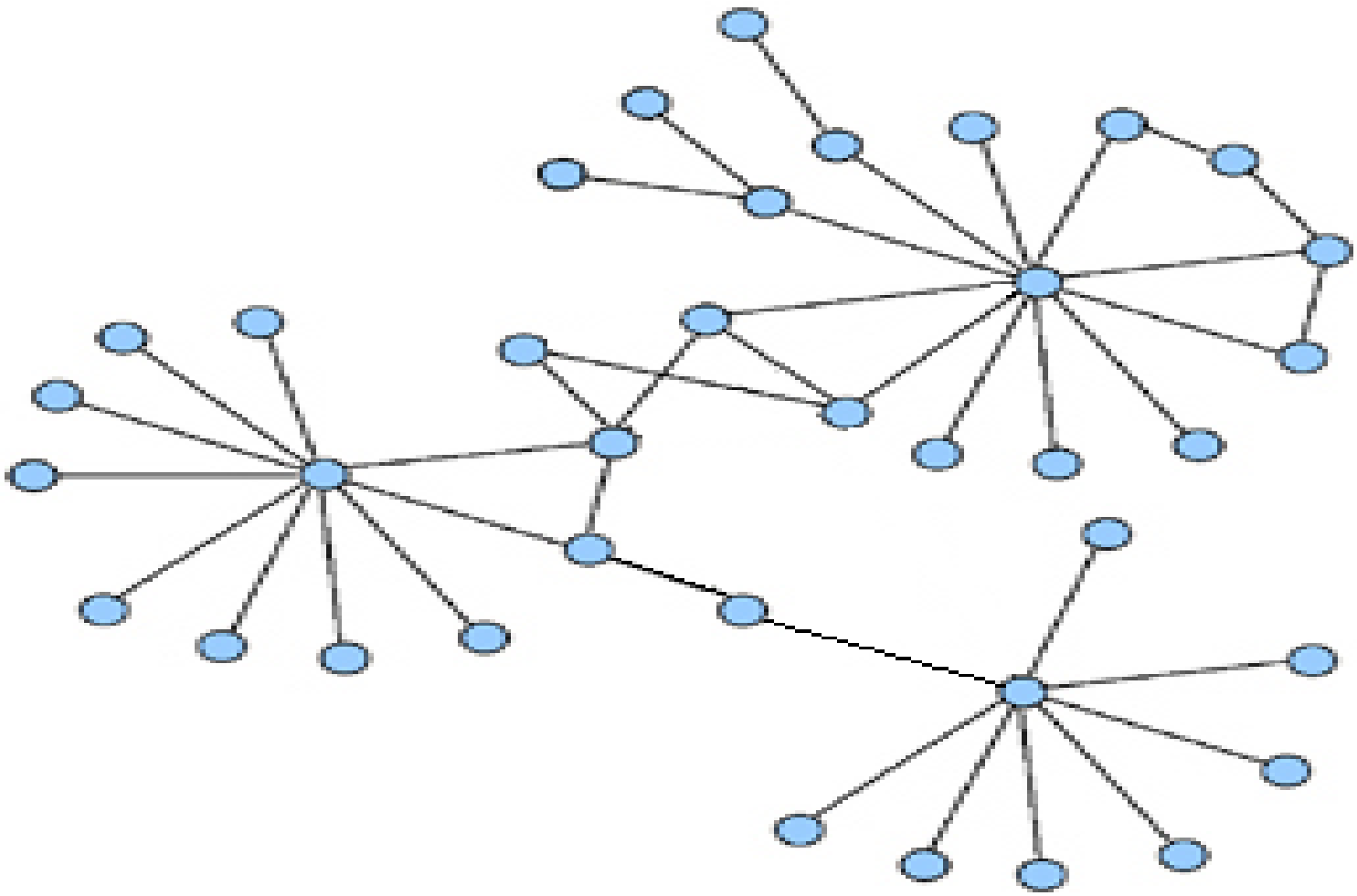
Random



Small world



Scale free



Networks (2)

- **The fundamental feature of networks is that they offer the basis for a different model of agent behaviour**
- 'Humans reason poorly and act intuitively': Daniel Kahneman, Nobel lecture, *American Economic Review*, 2003
- In this approach, agents do not process information and choose rationally. They copy what others have done
- Obviously, in practice there may be a mixture of the two: rational processing and copying
- Copying implies tastes and preferences are **not** fixed

Why Copy (1)?

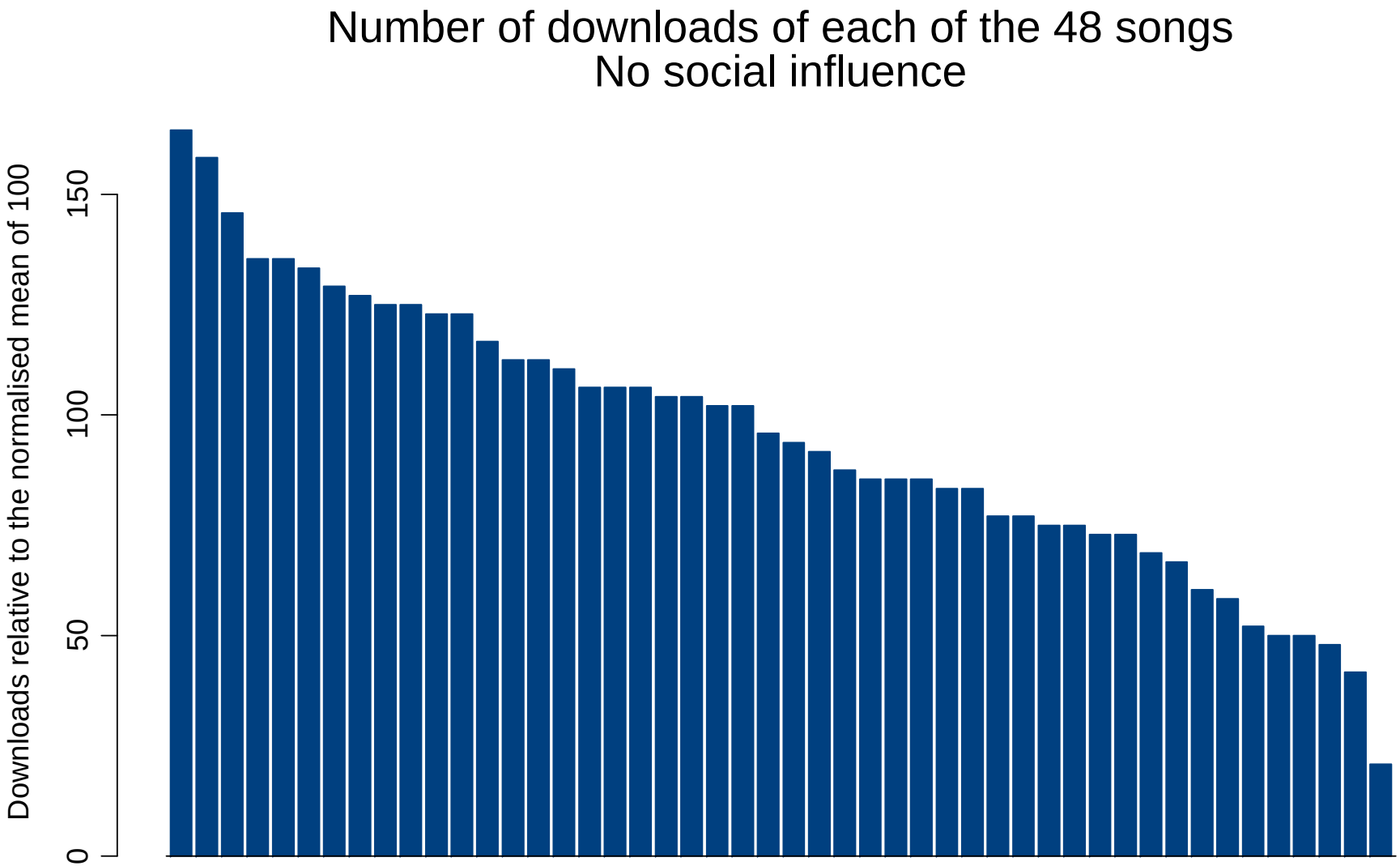
- Asch (1953 and 1955): *conformity*
- the behavior of an agent tends to become more similar to that of the group of which he or she is a member
- either because the agent believes the group to have better information than he or she does, or from a desire to conform to group norms
- *Peer acceptance*: 'it is ok to..... be obese, binge drink'
- Fowler and Christiakis, 'The spread of obesity in a large social network' , *New England Journal of Medicine*', 2007
- Ormerod and Wiltshire, 'Binge drinking in the UK: a social network phenomenon', *Mind and Society*, 2009

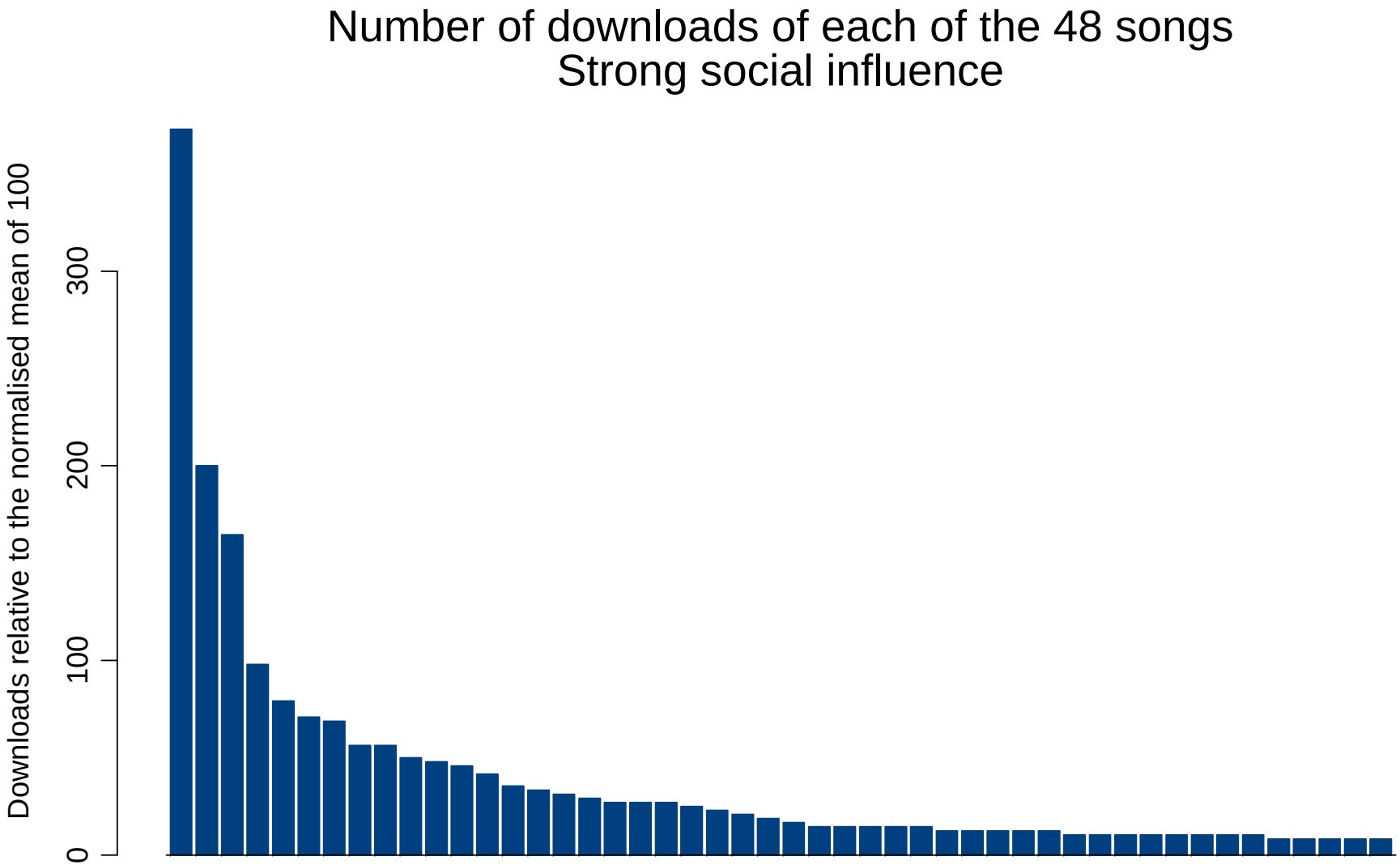
Why Copy? (2)

- ‘Social learning (learning through observation or interaction with other individuals) is widespread in nature and is central to the remarkable success of humans’; Rendell et.al. ‘Insights from the Social Learning Strategies Tournament’, *Science*, 9 April 2010
- ‘The most important outcome of the tournament is the remarkable success of strategies that rely heavily on copying... This outcome was not anticipated either by the organisers nor by the committee of experts established to oversee the tournament’
- Simple copying worked very well!

The music download experiment: an example of copying

- Salganik, Dodds, Watts, 'Experimental study of inequality and unpredictability in an artificial cultural market', *Science,* 2006
- Columbia students downloaded previously unknown songs either with or without knowledge of previous participants' choices
- *Increasing the strength of social influence increased both inequality of outcome and unpredictability of success*
- Success was also only weakly determined by quality: the best songs rarely did poorly, and the worst rarely did well
- *But any other result was possible i.e. outcomes are only weakly determined by intrinsic quality of the product*


Number of downloads of each of the 48 songs
No social influence
Downloads relative to the normalised mean of 100
0
50
100
150


Number of downloads of each of the 48 songs
Strong social influence
Downloads relative to the normalised mean of 100
0
100
200
300

Copying in practice: examples

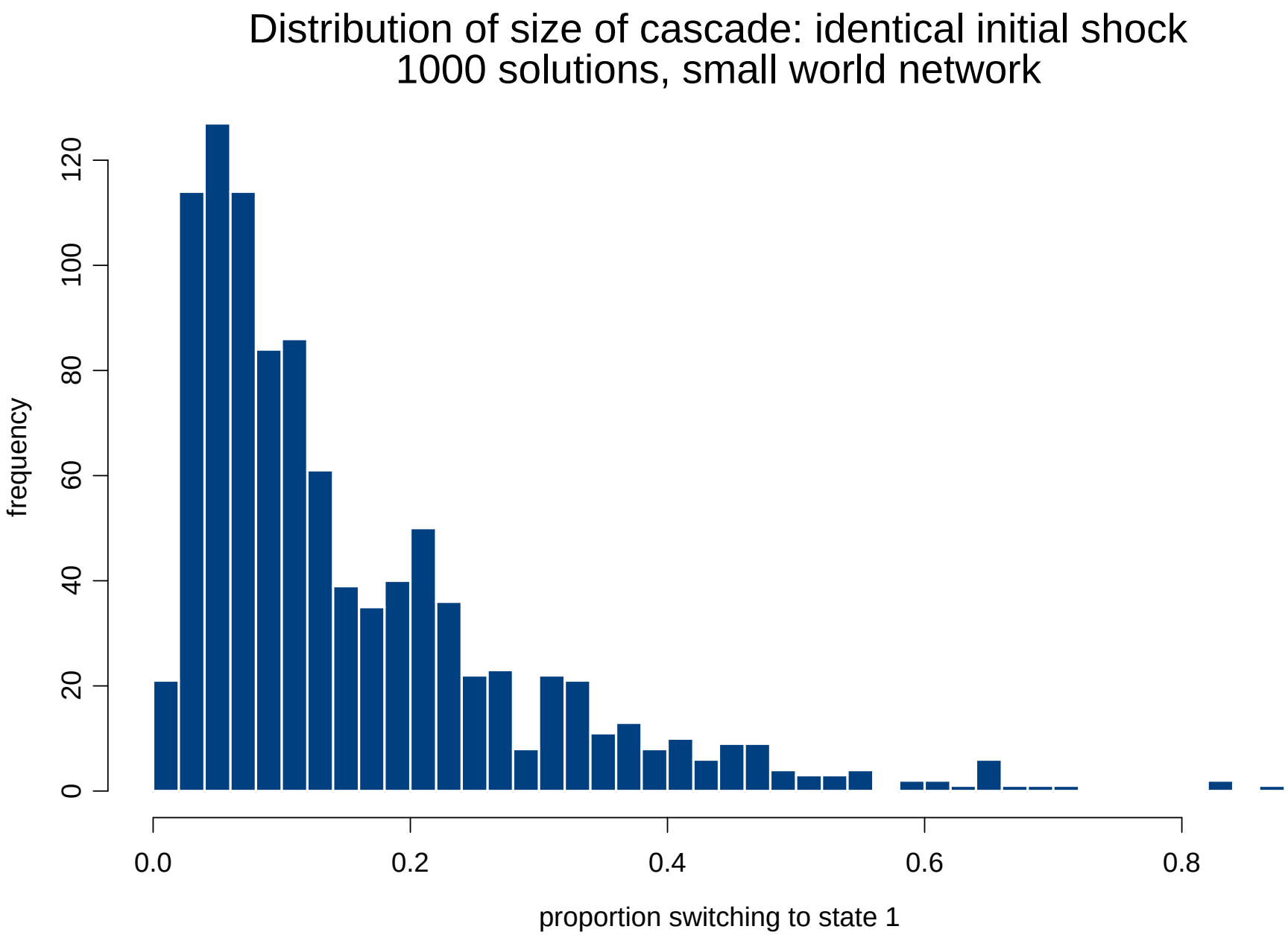
- *popular culture* e.g. Bentley et.al. 2007, De Vany 2004, Kretschmer et.al. 1999, Walls 2005
- *the adoption of innovations* e.g.,Arthur 1989, Rodgers 2003, Young 2005, Bettencourt et al. 2006
- *diffusion of criminal behaviour* e.g. Glaeser et al. 1996, Ormerod et.al. 2004
- *diffusion of sociopolitical behaviors* e.g. Lohmann 1994, Nowak et al. 2000, Hedstrom et al. 2000, Colbaugh and Glass 2009
- *sales in online markets* e.g., Leskovec et al. 2006, Dhar and Chang 2007
- *trading in financial markets* e.g. Kirman 1995, Shiller 2000
- *rise and fall of fads and fashions* e.g. Schelling 1973, Bikhchandani et al. 1998
- *sentiment in the business cycle* e.g. Ormerod 2001, 2004, Xi and Wang 2010

A simple but powerful model of copying across a network

- The decision of any given agent is governed not just by the standard set of incentives but by the decisions of others
- 'Binary choice with externalities' Schelling, 'Hockey helmets, concealed weapons, and daylight saving: a study of binary choices with externalities', *Journal of Conflict Resolution*, 1973
- The theoretical model is that of Watts, 'A simple model of global cascades on random networks', *Proceedings of the National Academy of Science*, 2002
- This has a fixed network, Ormerod and Colbaugh extend this to networks which evolve as agents seek to increase fitness ('Cascades of failure and extinction in evolving social networks ' *Journal of Artificial Societies and Social Simulation*, 2006)

Percolation across a network

- Agents can be in one of two states of the world, 0 or 1 [e.g. Not buy/buy; optimistic/pessimistic; believe ideology X or ideology Y; solvent/insolvent]
- Initially all agents are in state 0
- A small number are chosen at random to switch to state 1. How far does the cascade spread?
- Agents are heterogeneous. Each agent allocated at random a threshold on a uniform distribution on [0,1]
- An agent switches state of the world if the proportion of agents it is connected to in that state of the world is above its threshold
- Solve the model N times and observe the distribution of cascades


Distribution of size of cascade: identical initial shock
1000 solutions, small world network
frequency
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
proportion switching to state 1

Reflections

- Standard theory remains applicable where the assumption of fixed tastes and preferences is reasonable
- Network theory can help extend the concept of bounded rationality
- But in many contexts, copying/imitation across networks forms a more realistic view of agent behaviour
- Incentives and ‘rational’ behaviour *combined with* networks is the more general approach