Rationality, evolution and extinction in social and economic systems

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Rational decision making

- Agents choose independently
- Agents have fixed tastes and preferences
- Agents gather all information about alternatives
- Subject to constraints such as income, they make the optimal choice
- Limited/asymmetric information – agents still maximise subject to this additional constraint
- Behavioural economics
- There is a correct, rational way to behave, and irrational deviations are observed

Rational expectations

- Agents know the true model of the system
- They use this to form expectations about the future
- Their predictions may be incorrect in every single period, but *on average*, over a long but unspecified period of time, they will be correct
- There is a large literature on how agents learn the true model
- But once they have the model, only random shocks can cause agents to fail
- We might usefully observe that economists themselves still disagree about the true macro model of the economy e.g. does austerity work or not?

Failure and extinction in reality

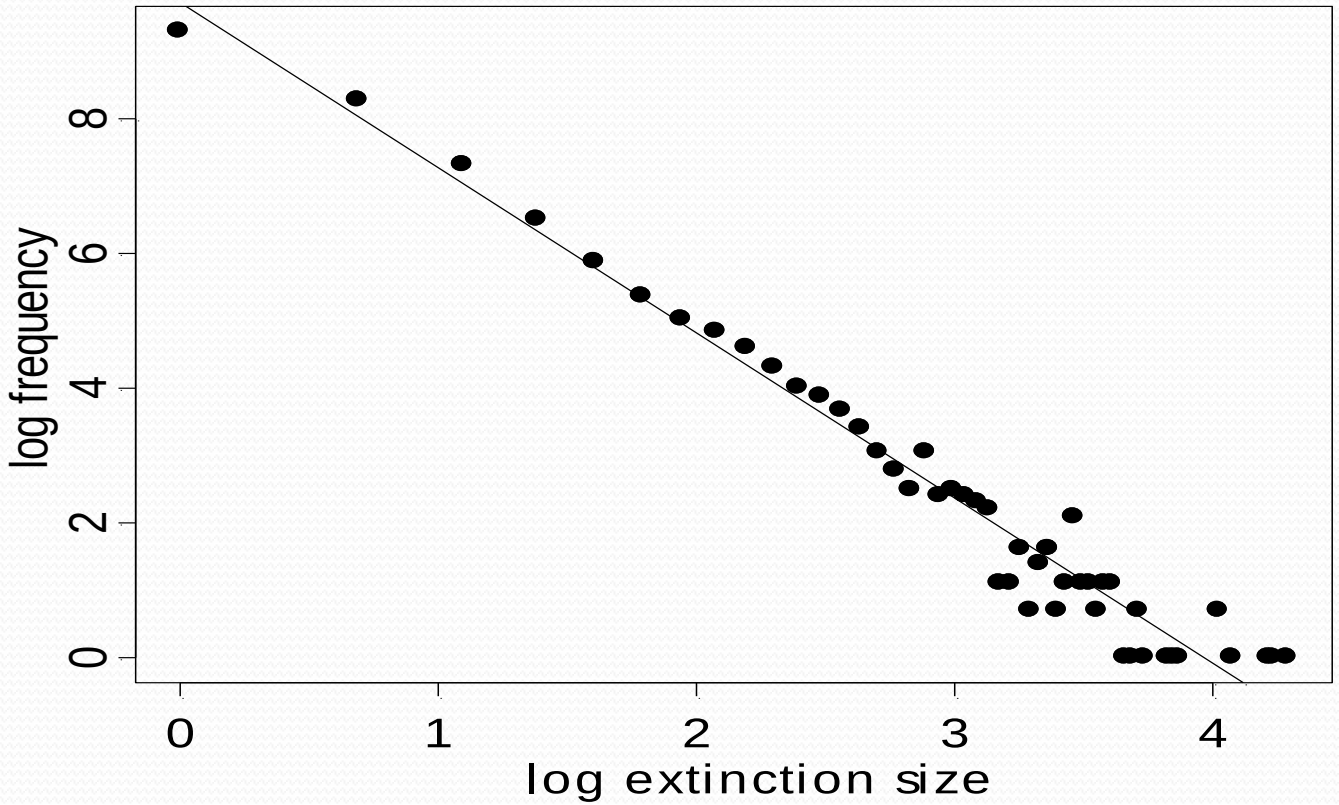
- Almost 100 per cent of all biological species which have ever existed are extinct
- Almost 100 per cent of all firms which have ever existed are extinct
- Hannah (1999) for example: the 100 largest firms in the world in 1912; by 1995, 48 had disappeared completely, and only 19 were still in the top 100
- Firm failure rates are high initially, and then stabilise
- Longevity is only weakly related to size
- The size/frequency pattern of extinction of both species and firms can be approximated by a power law with exponent around -2

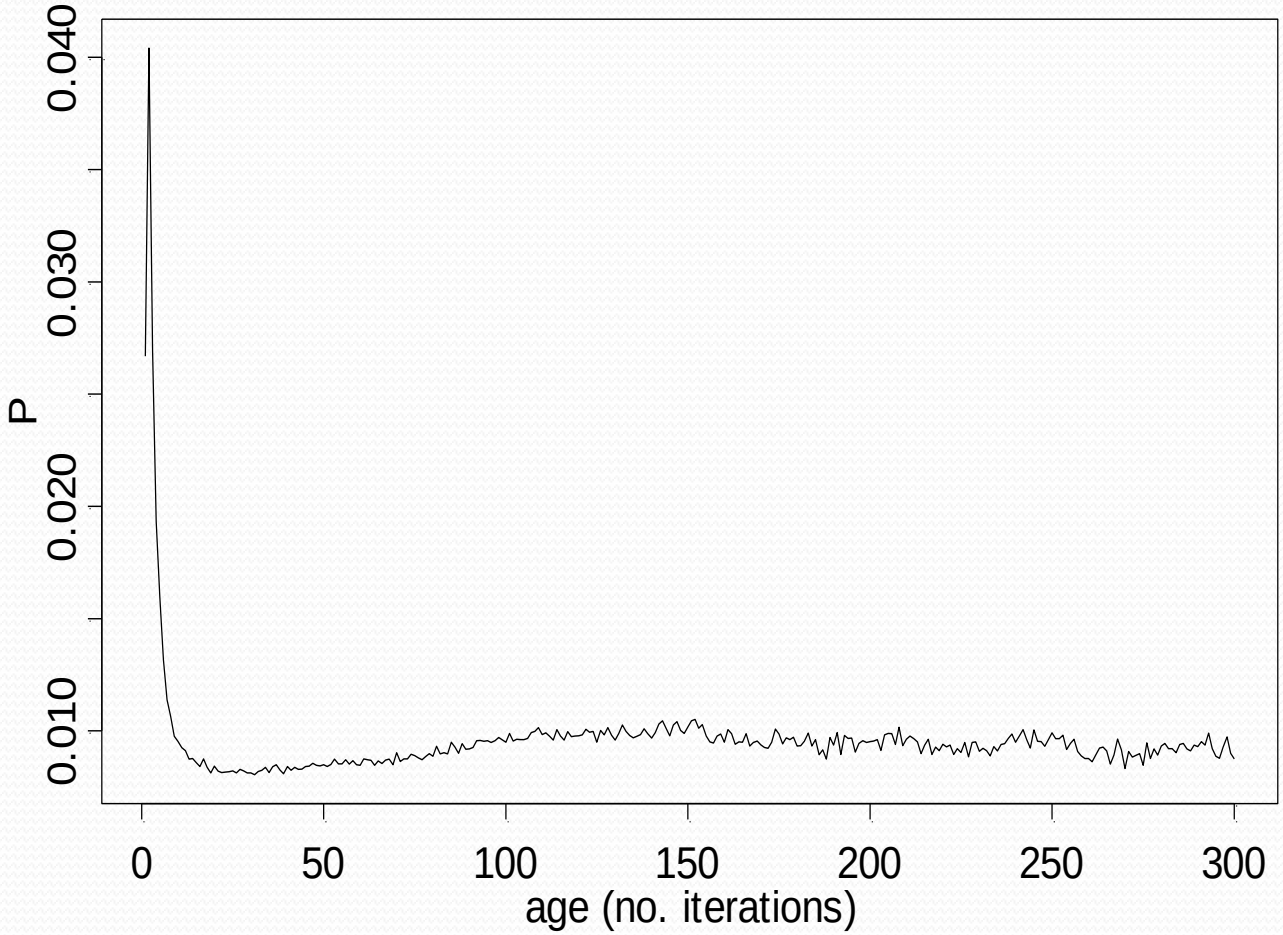
A theoretical model

- N agents influence each other via a matrix of uniformly distributed interconnections $J_{ij} \in [-1, 1]$, where J_{ij} is the effect of agent i upon agent j
- J_{ij} is initialised by drawing at random from a uniform distribution on [-1, 1]
- Each agent i has one of its J_{ji} updated, i.e. assigned with a new value chosen at random in the interval [-1, 1]
- The fitness $F_i(t)$ of each agent is calculated as the sum of J_{ji}
- If $F_i(t) < 0$ then the agent is deemed extinct and its interconnections are obsolete, i.e. $J_{ij} = 0$ and $J_{ji} = 0$ for all j.

A few remarks

- Within reason, the properties of the model are invariant to the replacement rule
- When $J_{ij}, J_{ji} > 0$, firms benefit from each other. This is in fact the norm in modern economies
- $J_{ij} > 0, J_{ji} < 0$ is general competition and $J_{ij}, J_{ji} < 0$ intense e.g. A price war
- We can think of the updating rule as firms trying to maximise fitness by a process of trial and error
- Random shocks do not alter the properties of the model (unless their scale dominates the model)


log frequency
0
2
4
6
8
0
1
2
3
4
log extinction size


P
0.010
0.020
0.030
0.040
0
50
100
150
200
250
300
age (no. iterations)

Giving firms more knowledge

- the updated value is chosen at random from [-1, 1], but the agent is allowed to select the particular J_{ji} which is updated, rather than it being chosen at random
- This rule leads quite rapidly to extinctions becoming rare
- a parameter ε, $\varepsilon > 0$, is added to the value chosen at random in the uniform interval [-1, 1]
- We can let some firms do this, and not others
- Having some knowledge greatly improves the life expectancy of any individual firm
- But even relatively small amounts of knowledge across the system lead to the size/frequency extinction pattern breaking down

Linking back to economic theory

- Keynes, *QJE* 1937:'We have, as a rule, only the vaguest idea of any but the most direct consequences of our acts.....How do we manage in such circumstances to behave in a manner which saves our faces as rational economic men?'
- Hayek stressed the 'limits to knowledge' in social and economic systems
- Simon argued that the optimal decision can in general never be known even after the event (*QJE* 1955)

Decades ahead of his time

- Alchian, *JPE,* 1950, 'Uncertainty, Evolution and Economic Theory'
- The purpose of Alchian's paper is to modify economic analysis in order to incorporate incomplete information and uncertain foresight as axioms – he looks to evolution for inspiration
- The problem was that it was not possible to formalise this approach at the time

Alchian's argument

- He considers whether, even in the face of uncertainty, at least a local optimum might be found if firms follow what we would now term a Bayesian learning process
- For convergence to an equilibrium, he argues that two conditions need to be satisfied.
- A particular trial strategy must be capable of being deemed a success or failure *ex post*
- The position achieved must be comparable with results of other potential actions
- It is unlikely that such conditions will hold in practice, for the simple reason that the external environment of a firm is not static but changing
- Comparability of resulting situations is destroyed by the changing environment.

Implications for models of agent behaviour

- **In these conditions, we need at least one different 'null' model of agent behaviour to replace that of rational choice**
- Alchian argues that "in general, uncertainty provides an excellent reason for **imitation** of observed success".
- Remarkable confirmation of this in Rendell et al., *Science*, 2010 'Why Copy Others? Insights from the Social Learning Tournament'
- Economics has 'imitation' models of behaviour e.g. Herding
- But these are seen as the special case, whereas they are in fact they are the general
- Models from cultural evolution, in which agents are neutral to the attributes of alternatives, perform very well on many empirical data sets (outcomes are typically highly non-Gaussian)
- Bentley, Ormerod, Batty (2011); Bentley, Caiado, Ormerod (2014)