Challenges for Econophysics and Complexity Science

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Overview: complex systems and economics

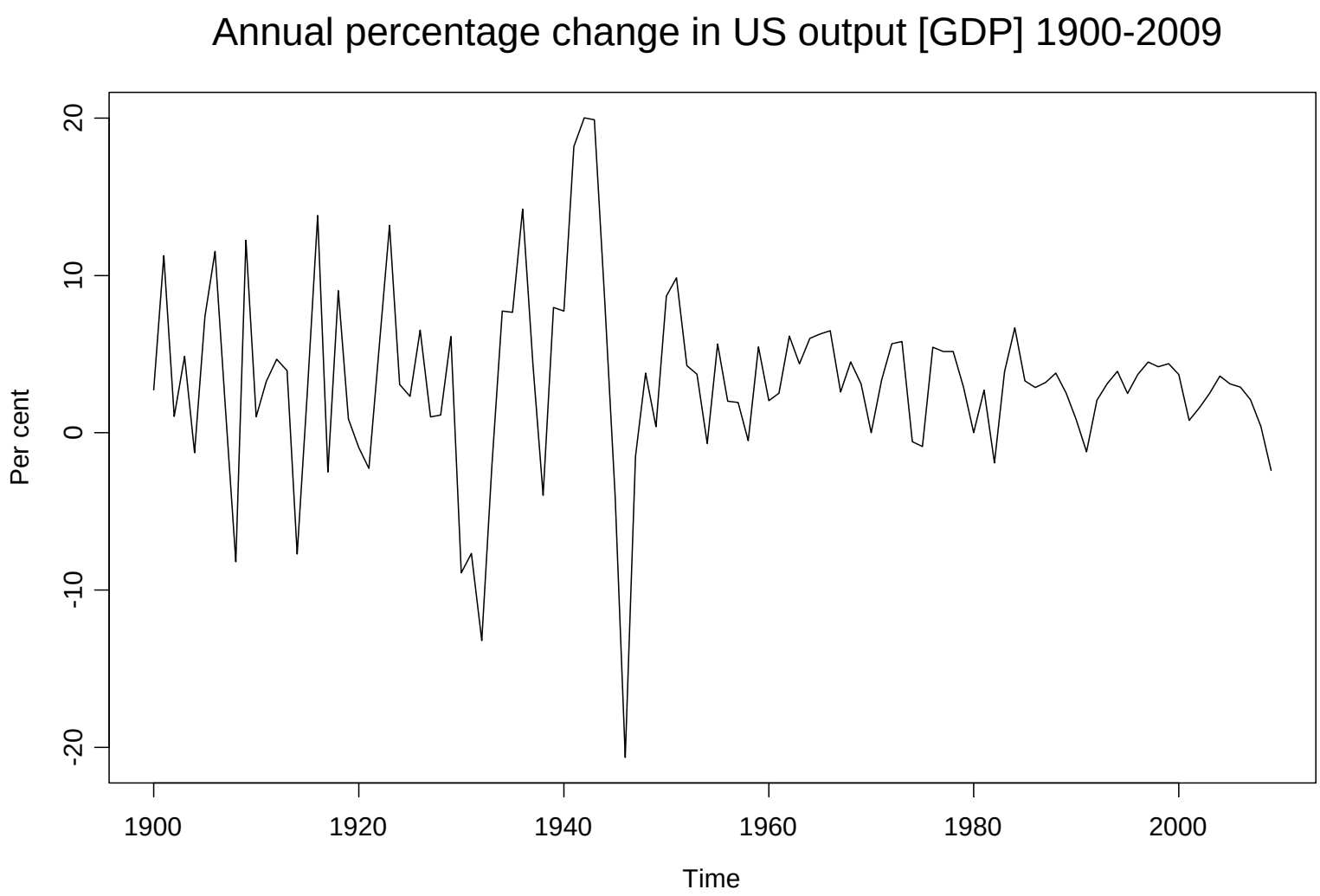
- Successes of econophysics: why is it not accepted much more widely?
- The mindset of mainstream economics
- Self-imposed restrictions of econophysics
- Weaknesses of econophysics
- The gulf between economics and econophysics
- Illustrative example

Self-imposed restrictions

- Although the situation is improving, most data sets in the social science are short and noisy – many econophysicists reluctant to work with such data
- An example of two major scientific challenges where economics lacks satisfactory theories:

  - the long-run steady growth of the capitalist economies which distinguishes them very dramatically from all previously existing societies

  - the short-run fluctuations around long-run growth which appear to be a persistent and inherent feature of these economies


Annual percentage change in US output [GDP] 1900-2009
Per cent
20
10
0
-10
-20
1900
1920
1940
1960
1980
2000
Time

Weaknesses of complex systems theorists and economics

- Lack of knowledge of what has already been done
- Lack of knowledge of (some) economic theory
- Economics is not a completely empty box
- Power laws are very important to physicists but not to social scientists: Gaussian or non-Gaussian?
- Weak statistical analysis [R Perline, 'Strong, weak and false inverse power laws', *Statistical Science*, 20, 68-88, 2005]

Agent behaviour

- Economics has the **rational agent**
- Modified by bounded rationality, which places restrictions on the set of information available, but not on the processing of this by the agent (optimality is retained)
- Econophysics /complex systems has the '**particle**'
- This has zero intelligence, cannot learn, acts at random
- Modified by small amounts of knowledge/ability to process this
- **There is a profound gulf between these two views on the fundamental building blocks of models in the social sciences**

Which modelling strategy (1)?

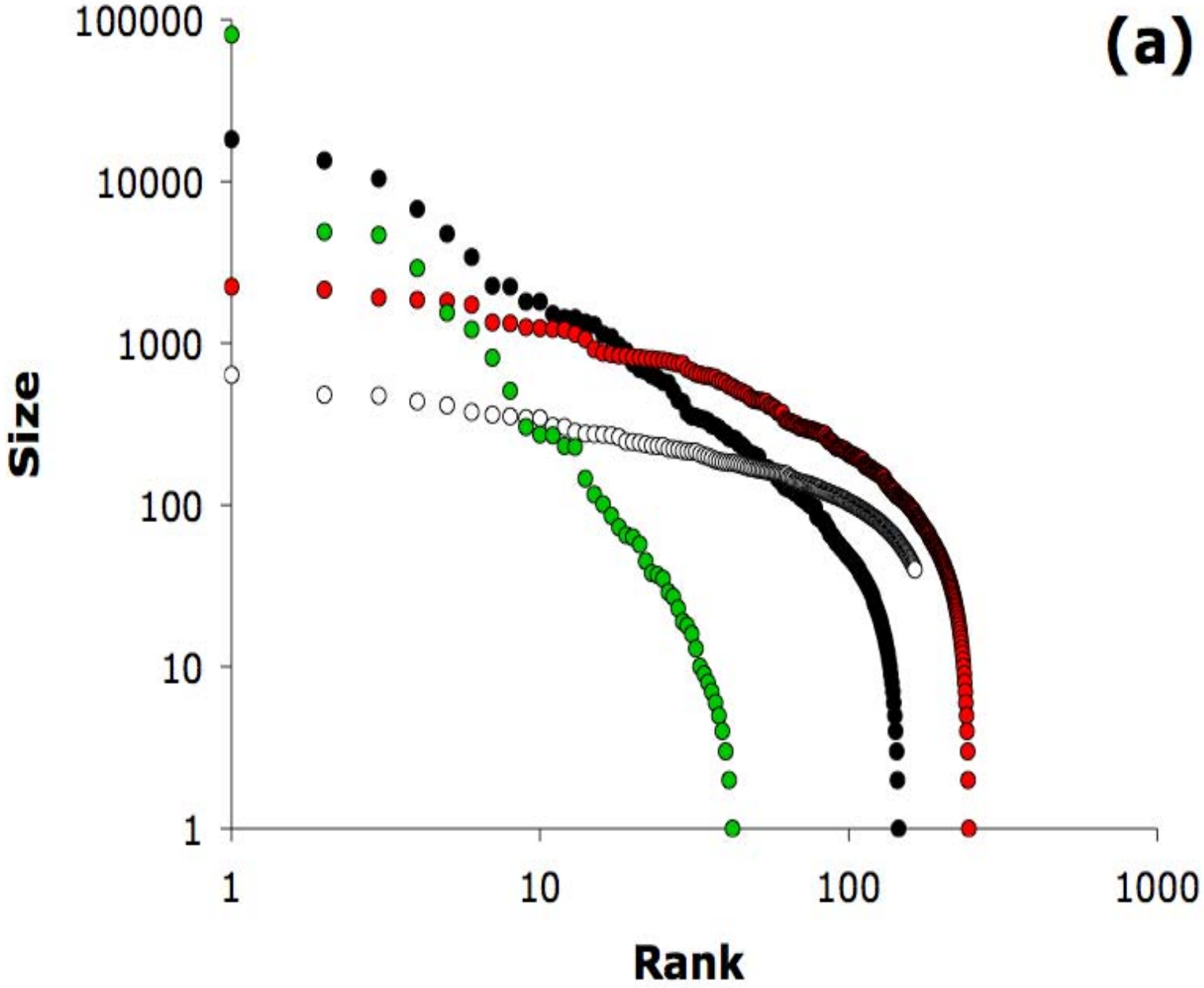
- Do we modify rationality or modify the 'particle' model?
- Lots of evidence to suggest that the latter is more realistic in most contexts
- 'Social learning ' [copying/imitation] is known to be widespread in human behaviour
- This implies the key importance of networks , capturing these correctly may be more important than the precise behavioural rules attributed to the nodes (agents)
- Alex Bentley and Paul Ormerod 'Agents, intelligence, and social atoms' in *Integrating Science and the Humanities* (M. Collard and E. Slingerland, eds.) Oxford University Press, forthcoming, 2010 www.paulormerod.com

Illustrative model (1)

- Alex Bentley, Paul Ormerod and Mike Batty, 'Evolving social influence in large populations', *Behavioral Ecology and Sociobiology*, 2010, forthcoming
- A general, parsimonious model of neutral choice by agents
- Generates an entire family of non-Gaussian distributions e.g. winner take all, exponential, power law of varying exponents in the tail, power law across the whole data
- Barabasi-Albert preferential attachment is a special case of this more general model
- The model generates continuous turnover in rankings – a key feature of the real world – naturally, without any artificial 'add-ons'

Illustrative model (2)

- Model initially populated by N agents in a space such as the sequence of real numbers
- In each step, n new agents enter
- With probability (1-μ) they select a location on the basis of preferential attachment
- With probability μ (where empirically $\mu < 0.1$), they select an entirely new location
- How many previous time steps of the decisions of other agents does an agent take into account? (m)
- Special cases of $m = 1$ and m = 'all' are known in the literature
- We allow m to take any value


(a)
100000
10000
1000
100
10
1
Size
1
10
100
1000
Rank

Which modelling strategy? (2)

- Sociology, anthropology, social simulation, psychology, geography are all potentially much more sympathetic to the econophysics view of agent behaviour than is economics
- Econophysics needs to widen its contacts and collaborations into these fields
- Econophysics has a view of agent behaviour which is scientifically based
- Econophysics has powerful modelling skills
- Its future is bright (though perhaps not with economists!)