

The Economics of Radical Uncertainty

Paul Ormerod

Centre for Decision Making Uncertainty, University College London (UCL)

March 2014

p.ormerod@ucl.ac.uk

Abstract

In situations of what we now describe as radical uncertainty, the core model of agent behaviour, of rational autonomous agents with stable preferences, is not useful. Instead, a different principle, in which the decisions of an agent are based directly on the decisions and strategies of other agents, becomes the relevant core model. Preferences are not stable, but evolve. It is not a special case in such circumstances, but the general one.

I provide empirical evidence to suggest that for consumers in the modern world, economic rationality is only applicable in a relatively small number of situations. I discuss models drawn from the modern literature on cultural evolution, and suggest a heuristic way of classifying situations in which the different models are relevant.

I then argue that many of the decisions facing firms and governments require a further additional theoretical layer, namely the theory of conviction narratives, which can be used to operationalise Keynes' concept of animal spirits.

The key point is that in situations where radical uncertainty is present, we require theoretical 'null' models of agent behaviour which are different from those of economic rationality. Under uncertainty, fundamentally different behavioural rules are 'rational'.

1 Introduction: Alchian, uncertainty and evolution

Much of the discussion in economics about decision making under uncertainty is framed in the context of the works of Frank Knight and JM Keynes. There is a relative neglect of a brilliant paper written by Armen Alchian in 1950¹. Alchian considers uncertainty and economic theory from an evolutionary perspective. He anticipates by decades many of the insights of the modern mathematical articulation of the theory of evolution (for example, Sole and Manrubia 1997, Newman 1996, Ormerod 2005)².

The purpose of Alchian's paper is to modify economic analysis in order to incorporate incomplete information and uncertain foresight as axioms. He argues, in a way which is now familiar, that "uncertainty arises from at least two sources: imperfect foresight and human inability to solve complex problems containing a host of variables even when an optimum is definable". Alchian's own discussion is set in the context of the behaviour of firms in such situations, but he suggests that the argument is readily transferable to consumer behaviour.

I argue below that there are important differences in the role of uncertainty in the types of decisions which firms and government often have to make, and the typical decision facing consumers. However, modern variants of the 'null' model put forward by Alchian are the relevant ones for both individuals and companies. By 'null' is meant the principles underlying the basic model of behaviour, which can obviously be adapted and extended if necessary. Many of the decisions of firms and governments require an additional layer on the null model.

Alchian begins by considering a model, albeit descriptive rather than formal, in the context of firms. Profits remain the criterion by which the economic system selects survivors. However, "It does not matter through what process of reasoning or motivation such success was achieved. The fact of its accomplishment is sufficient". In this model, individual rationality, motivation and foresight are temporarily abandoned, and the outcome is determined by sheer chance. It is as if the environment adopts the successful survivors, rather than the survivors adapting their own behaviour to the environment. Ormerod and Roswell (2003)³ show that a formal model of this kind generates results which are consistent both with the highly non-Gaussian distribution of the size-frequency relationship of firm

¹ AA Alchian, 'Uncertainty, Evolution and Economic Theory', *Journal of Political Economy*, 58, 211-221, 1950

² For example, M. E. J. Newman, 'A model of mass extinction', *J. Theor. Biol.*, 189, 235-252, 1997; R.V. Solé and S.C. Manrubia 'Extinction and self-organized criticality in a model of large-scale evolution', *Phys. Rev E* 54:1 R42, 1996; P Ormerod, *Why Most Things Fail: Evolution, Extinction and Economics*, Faber and Faber, London, 2005

³ P Ormerod and B Rosewell, 'What Can Firms Know?', *Proceedings of the North American Association for Computational Social and Organisational Sciences*, Pittsburgh, 2003

extinctions (for example, Di Guilmi et al. 2004⁴), and with the probability of extinction of any given firm with respect to its age (for example, Carroll and Hannan 2000⁵).

This model is very similar to the modern unified theory of biodiversity (Hubbell 2001⁶), which was developed to explain both the diversity and the relative abundance of species at a point in time in ecological communities. The postulate is that no species has any particular fitness advantage. In other words, the attributes of a species are irrelevant to their relative success or failure. The outcome in terms of relative abundance is 'neutral' with respect to the attributes of species. The theory is not without its critics, but it does seem to be consistent with the non-Gaussian distributions which are observed empirically.

2. Purpose and intent under uncertainty

Alchian then goes on to take into account that humans are not like other species. We can imagine the future, act with purpose and intent and consciously adapt our behaviour. He postulates that, 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. However, 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*, and the position achieved must be comparable with results of other potential actions. Alchian argues that 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.

How, then, are agents to behave in the face of uncertainty? It is here that, in my view, his paper is at its most profound. Alchian argues that "in general, uncertainty provides an excellent reason for imitation of observed success". He also suggests that there is also a role for innovation, in addition to the dominant behavioural rule of imitation. I return to the combination of these two motivations shortly, but first consider the implications of imitation.

Economic theory certainly contains models in which imitation is the main driver of behaviour in, for example, herding models. But these are seen as a special case compared to the more generally applicable model in which agents have fairly stable preferences and select on the basis of the attributes of the alternatives which are available. Alchian argues, all those years ago, that under changing external environments – under uncertainty – the

⁴ C Di Guilmi, M Gallegati, P Ormerod, 'Scaling invariant distributions of firms' exit in OECD countries', *Physica A*, 334, 267-273., 2004

⁵ G.R.Carroll and M.T.Hannan, *The Demography of Corporations and Industries*, Princeton, 2000

⁶ SP Hubbell, *The Unified Neutral Theory of Biodiversity and Biogeography*, Princeton, 2001

model in which agents imitate the behaviour of others is the general principle of behaviour, and not just the special case.

3. Experimental and empirical evidence

An important paper in *Science* confirms this intuition (Rendell et al. 2010)⁷. It is worth quoting from this paper at some length. Rendell and his co-authors come from a wide range of disciplines, although there are no economists. For them, “Social learning (learning through observation or interaction with other individuals) is widespread in nature and is central to the remarkable success of humanity”. A list of references is cited in support of this point. In other words, they start from Alchian’s position that imitation is a key driver of behaviour. However, the motivation for the paper is that “it remains unclear why copying is profitable and how to copy most effectively. To address these questions, we organized a computer tournament in which entrants submitted strategies specifying how to use social learning and its asocial alternative (for example, trial-and-error learning) to acquire adaptive behavior in a complex environment”.

A computer tournament was organised in which strategies competed in a complex and changing simulation environment. My fellow economists will be pleased to know that, in addition to the prestige of designing the winning strategy, there was a cash prize of 10,000 Euros. Entered strategies had to specify how individual agents in a finite population choose between three possible moves in each round, namely Innovate, Observe, and Exploit. Innovate represents individual learning, in which accurate information is relayed to the agent about the pay-off to a potential strategy. Observe gave noisy information about the behaviour and payoff currently being demonstrated in the population by one or more other agents playing Exploit. Finally, Exploit involved an agent actually playing a strategy and obtaining a pay-off. A key feature of the tournament was that the pay-offs to any given strategy were not time-invariant.

The results of the tournament were a surprise to the organisers: “Most current theory predicts the emergence of mixed strategies that rely on some combination of the two types of learning. In the tournament, however, strategies that relied heavily on social learning were found to be remarkably successful.... Indeed, the winning strategy relied nearly exclusively on social learning”. In other words, Alchian’s view that imitation – social learning – is a very sensible behavioural rule for agents operating in the face of uncertainty is supported strongly by the results of the tournament.

An obvious question which follows from this is an empirical one. Namely, to what extent do real life markets exhibit key features of uncertainty – essentially, an environment which is too complex to permit rational analysis? From a consumer perspective, there is certainly

⁷ ‘Why Copy Others? Insights from the Social Learning Tournament’, *Science*, 308, 208-213, 9 April 2010

evidence that this is increasingly a feature of many markets. The number of alternative choices which is available has expanded dramatically in recent decades. Further, their attributes often differ in numerous minor ways which are difficult to comprehend.

Beinhocker (2007)⁸, for example, notes that: “The Wal-Mart near JFK Airport has over 100,000 different items in stock, there are over 200 television channels offered on cable TV, Barnes and Noble lists over 8 million titles, the local supermarket has 275 varieties of breakfast cereal, the typical department store offers 150 types of lipstick, and there are over 50,000 restaurants in New York City alone.” At the stock keeping unit level (SKU), the level of product detail at which retailers specify their restocking orders, Beinhocker estimates that on a single day in New York, there are 10 billion (!) such choices available. There may indeed be objective differences between the various offers, but in such numerous, minor and often incomprehensible ways that they exemplify what has come to be called ‘decision quicksand’ by Sela and Berger (2011)⁹ or ‘decision fatigue’ by Baumeister and Tierney (2011)¹⁰.

As discussed by Ormerod et al. (2012)¹¹, given the huge amount of choice which has emerged in recent decades, the behavioural model of economics, namely that of rational selection on the basis of objective information, faces challenges, even when it is modified to take into account imperfect and asymmetric information. If rationality is defined as maximizing utility subject to constraints, but every possible good is effectively identical, then every good will be in the argmax of the utility function, and therefore every good will be chosen with equal probability.

4. Models of agent behaviour under uncertainty

Alchian suggest that in such circumstances of radical uncertainty, the appropriate decision rule is for agents to imitate the behaviour of others. Simon (1955a)¹² developed a model for the purpose of explaining the highly non-Gaussian right-skewed distributions which are a feature of many circumstances in both the socio-economic and the natural sciences. Ormerod (2012)¹³ gives examples of quite disparate right-skewed non-Gaussian outcomes from the social sciences: downloads on YouTube; film producers’ earnings; the number of sexual partners people have; the size of price changes in financial assets; crowds at soccer matches; firm sizes; the size and length of economic recessions; the frequency of different

⁸ E Beinhocker, *The Origin of Wealth*, Cambridge, MA: Harvard Business School Press, 2007

⁹ A Sela and J Berger, ‘Decision quicksand: how trivial choices suck us in’, *Journal of Consumer Research*, 39, 2011

¹⁰ R Baumeister and J Tierney, *Willpower*, New York: Penguin, 2011

¹¹ P Ormerod, B Tarbush and RA Bentley, ‘Do the attributes of products matter for success in social network markets?’, eds. C. Laroque, J. Himmelspach, R. Pasupathy, O. Rose, and A. M. Uhrmacher, *Proceedings of the Winter Simulation Conference*, Berlin, December 2012

¹² H A Simon, ‘On a Class of Skew Distribution Functions’, *Biometrika* 42, 425-440, 1955

¹³ P Ormerod, *Positive Linking: How Networks Can Revolutionise the World*, Faber and Faber, London, 2012

types of endgames in chess; sizes of cities; the ratings of American football coaches in *USA Today*; the distribution of £1 million homes across London boroughs; unemployment rates by county in America; deaths in wars; the number of churches per county in William the Conqueror's Domesday Book survey of England in the late eleventh century.

Simon's model is a good heuristic for imitative behaviour. Agents essentially choose with a probability equal to the number of times any given alternative has been selected as a proportion of the total number of selections made across the agents to which the agent is connected. They may, for example, regard other agents as having more information than they do, and hence copy their behaviour. This has become known as the principle of preferential attachment, following the rediscovery of Simon's model in the highly cited paper by Barabasi and Albert (1999)¹⁴.

The model of behaviour in which agents select on the basis of preferential attachment is capable of explaining many observed distributions of popularity amongst alternatives at a point in time. However, the second key distinguishing feature is that there is turnover in rankings over time. The time-scale of turnover may differ very substantially depending on the particular example. Changes in, say, the rankings of popular songs change rapidly, whereas changes in the relative sizes of cities are slow, but nevertheless they do take place (Batty, 2006)¹⁵.

Models of choice arising from the principles of cultural evolution are capable of generating both non-Gaussian outcomes of relative popularity at a point in time and turnover in rankings at a point in time. Essentially, agents select using the principle of preferential attachment with probability $(1 - \mu)$, and with probability μ innovate in the sense that they select an alternative which no-one has previously selected (for example, Hahn and Bentley 2003¹⁶, Shennan and Wilkinson 2001¹⁷). The model has been generalised to include the effects of memory (Bentley et al. 2011a)¹⁸, and a spatial dimension (Bentley et al. 2014)¹⁹. It is important to note that this modelling approach differs from that based upon the concept of rational addiction with preferences which are learned and are intertemporally dependent (for example, Becker and Murphy 1988²⁰, Britto and Barros 2005²¹). In this model, agents

¹⁴ A-L Barabasi and R Albert, 'Emergence of Scaling in Random Networks', *Science*, 286, 509-512, 1999

¹⁵ M Batty, 'Rank Clocks', *Nature*, 444, 592-596, 2006

¹⁶ MW Hahn and RA Bentley, 'Drift as a mechanism for cultural change: An example from baby names', *Proceedings of the Royal Society B*, 270, S120-S123, 2003

¹⁷ SJ Shennan and JR Wilkinson, 'Ceramic style change and neutral evolution: A case study from Neolithic Europe', *American Antiquity*, 66: 577-594, 2001

¹⁸ RA Bentley, P Ormerod and M Batty, 'Evolving Social Influence in Large Populations', *Behavioral Ecology and Sociobiology*, 65, 537-546, 2011

¹⁹ RA Bentley, CCS Caiado and P Ormerod, 'Effects of Memory on Spatial Heterogeneity in Neutrally Transmitted Cultures', *Evolution and Human Behavior*, forthcoming, 2014

²⁰ G Becker and K Murphy, 'A theory of rational addiction', *Journal of Political Economy*, 96, 675-700, 1988

²¹ P Brito, and C Barros, 'Learning by consuming and the dynamics of the demand and prices of cultural

are not required to learn preferences over time. At any point in time, an agent makes a choice based simply on the choices made by others, with a small probability of random innovation in making their selection.

5. A classifying heuristic

Bentley et al. (2011b²²) develop a heuristic for classifying the circumstances in which different kinds of models are the relevant ‘null’ models of behaviour with which to account for how agents select amongst alternatives. To emphasise, it is a heuristic and not in any way intended to be a complete set of criteria for such classification.

On the horizontal axis, we represent the extent to which agents select either independently or by copying/imitation. The vertical axis shows the relative ease with which the attributes of the alternatives can be distinguished.

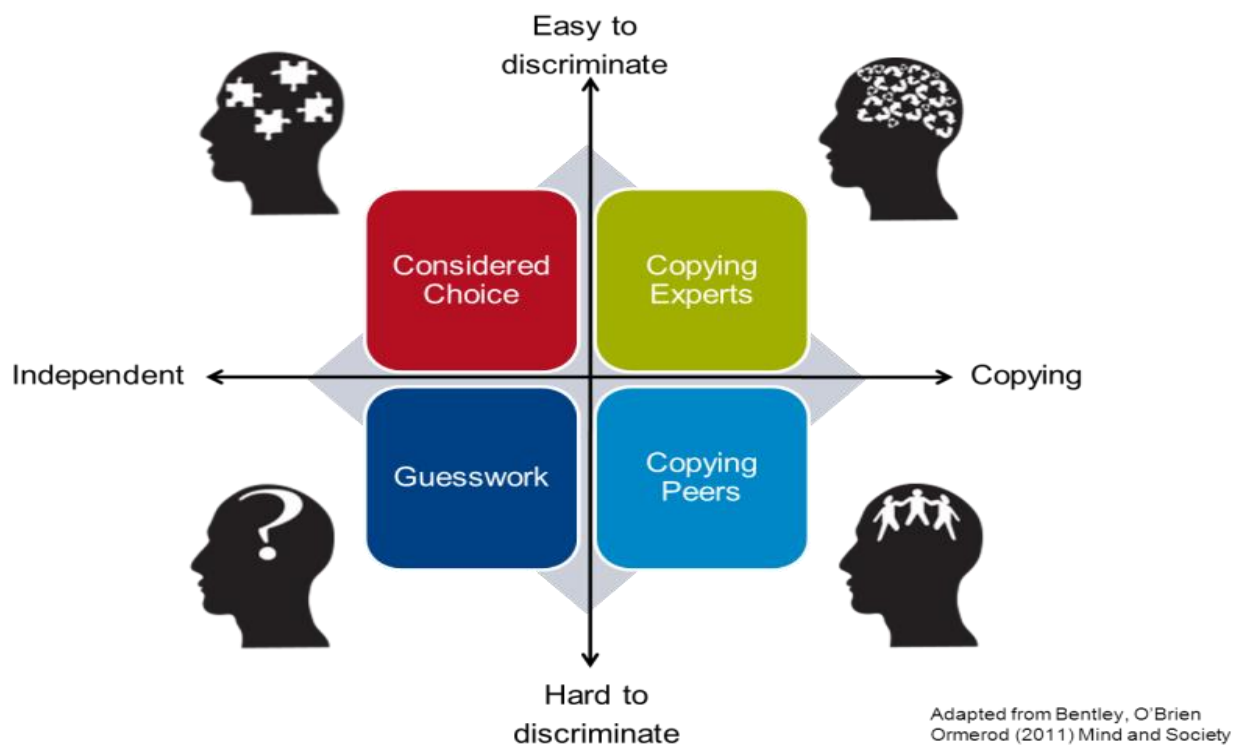


Figure 1 A heuristic for classifying situations in which different ‘null’ models of agent behaviour are appropriate

The top left hand box can be thought of as the area in which standard rational consumer choice theory is relevant. Social influence on choice is weak, and agents select primarily in an independent manner. The attributes of the alternatives are relatively easy to distinguish.

Goods’, *Journal of Cultural Economics*, 29, 83–106, 2005

²² RA Bentley, MJ O’Brien and P Ormerod, ‘Quality versus Mere Popularity: A Conceptual Map for Understanding Human Behaviour’, *Mind and Society*, 10, 181-191, 2011

This latter point can be unbundled into a number of different layers, which cannot be captured in a simple 4-box heuristic chart such as Figure 1. For example, the costs of gathering information about the alternatives should not be large. The number of alternatives should be relatively small, so that the agent is able to process the information. This much is obvious. But there is an implicit time dimension to the costs of gathering and processing information. Choices which have implications into the future may not have time-invariant costs associated with them. So, for example, at a point in time an agent can readily compare the rates of return of alternative asset portfolios. But attempting to understand the future rates of return is an altogether more challenging problem. In principle, an agent can attempt to gather and process information autonomously about the potential future rates, but this exercise starts to move us down into the bottom left-hand quadrant, where attributes are hard to distinguish.

As we move to towards the right of Figure 1, and social influence becomes more important as a driver of behaviour, uncertainty becomes more important as a feature of the environment. The suggestion underlying the two quadrants in this part of the chart is that the network structure which influences agents might plausibly differ. In the top right, for example, agents may copy a small number of other agents who either actually have, or are believed to have, genuine expertise in being able to distinguish the attributes of alternatives. A simple example is that of a wine columnist in a newspaper. Readers may reasonably believe that he or she has more ability to differentiate the qualities of different wines than they have. So implicit in this is a network which may have scale-free features. A small number of people may influence large numbers of others. In the bottom right, we have situations in which agents may rely more on the judgments of friends or family, or even work colleagues, people known to them. The networks of influence here will have more of a small world quality to them.

Figure 1 is, at the risk of repetition, simply a heuristic for classifying different situations in which different 'null' models of how agents make choices are appropriate. The key point is that the postulates of rational choice theory in economics are most relevant in situations in which uncertainty is low, the top left-hand quadrant of the chart.

6. Firms, governments and conviction narratives

The behavioural models discussed above are particularly relevant to consumers. A new dimension is introduced, when we consider many of the major decisions made by companies and governments. The most basic difference between these and almost all consumption decisions is that these are often one-off situations, where copying may have limited applicability simply because of a lack of comparable situations in which other agents are making, or have already made, decisions

To take an actual example from the UK at the present time, the government is contemplating building, at huge expense, a new high speed rail line between the North of England and London (High Speed 2, as it is known). Now, many high speed lines have been built around the world, and there is some value in examining the costs and impacts of such lines. However, each of these lines has many unique features, and it is hard to generalise from these examples to provide evidence either for or against HS2, which also has its own very specific characteristics. A major infrastructure project, the largest in Western Europe, which is actually taking place, is Crossrail, a project which involves massive new tunnels underneath the whole of Central London. In making the decision to go ahead with this project, it would not have made sense to look for examples to copy, because there are none. The same difficulty in finding reasonably comparable situations characterises many major capital investment decisions made by companies.

A further distinguishing feature of large government and corporate investment decisions is that they are hard to reverse. The capital stock, to use the jargon of the growth theory of the 1960s, is 'putty-clay'. *Ex ante*, many configurations are possible. *Ex post*, it is very difficult to turn it into something else.

Perhaps the most important aspect of investment decisions is that their impact takes place over many years. The environment can change in so many completely unanticipated ways that attempting to compute the optimal decision now is an exercise which makes very little sense. This is the context in which Simon (1955b)²³ introduced, in his seminal paper on behavioural economics, the concept of satisficing. Modern economics has neutered the impact of this concept, and redefined it to mean that it is simply a way in which agents deal with the costs of gathering and processing information. An agent examines alternatives, and once a satisfactory one is found, judges that the costs of further searching and processing for the optimal choice outweigh the increase in benefits.

Simon, however, regarded satisficing as meaning a heuristic rule of behaviour which agents used in situations where the optimal choice can never be known, even *ex post*. He used the game of chess as an example. The game of chess is in principle very simple. There are about a dozen rules, which can be learned easily. The object of the game is unequivocal, to capture the opponent's King. And you know everything which your opponent has done. But in most situations in the game, the optimal move cannot be computed. Many bad options can be eliminated, and players like Carlsen, the world champion, will do this much more effectively than an average player. Even at world championship level, this is how most games are lost and won. It is not often a matter of superior rational calculation of the consequences of a move. It is the judgment about what constitutes a good move. Do computers help? All positions with six pieces have now been solved. But there are 32

²³HA Simon, 'A Behavioral Model of Rational Choice', *The Quarterly Journal of Economics*, 69, 99-118, 2011

pieces in chess, and the computational complexity scales super-exponentially with the addition of each piece.

How, then, do agents make decisions in such situations? Faced by massive uncertainty, lacking reliable comparator examples to form the basis for a strategy of copying, how are they able to make any decision, rather than being paralysed by the complexity of the situation?

The fact is that people *do* make decisions. Throughout history innovation and investment repeatedly take place despite the ready availability of “rational” objections to action. Canal builders, railway builders, opera house builders, airport builders, dotcom entrepreneurs and many others all took action without knowing what the outcome would be. The results of their willingness to act on their vision allow us to use what they left behind, albeit that in many cases expectations were not fulfilled and actions led to bankruptcy and disappointment. In the long run there can be little doubt that their decisions enhanced welfare.

This is the context in which, of course, Keynes introduced his famous concept of animal spirits. The animal spirits which drive the marginal efficiency of capital are a psychological concept rather than one which is amenable to rational calculation. In the *General Theory*²⁴, he writes, for example, that ‘Most, probably, of our decisions to do something positive ...can only be taken as a result of animal spirits — of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities’ (p.161). He goes on: ‘Enterprise only pretends to itself to be mainly actuate by the statements in its own prospectus...only a little more than an expedition to the South Pole is it based upon benefits to come. Thus if the animal spirits are dimmed and spontaneous optimism falters, leaving us to depend on nothing but mathematical expectation, enterprise will fade and die’.

Until recently, the tools required to formalise and test the insight that psychological states such as animal spirits drive the economy did not exist. These are:

- The theory of conviction narratives which, when used in combination with algorithmic text analysis, permits the measurement of psychological states.
- The theory of networks, and in particular how sentiment percolates across relevant networks

Chong and Tuckett (2014²⁵), building on empirical work by Tuckett (2011²⁶, 2012²⁷) define conviction as a state of mind of an individual and confidence as an emotional state

²⁴ JM Keynes, *The General Theory of Employment, Interest and Money*, Macmillan, London, 1936

²⁵ Chong, K., and Tuckett, D. (2014) Constructing Conviction through Action and Narrative: How Money Managers Manage Uncertainty and the Consequences for Financial Market Functioning’. Accepted and in press at *Socio-Economic Review*

belonging to a collective, such as a group or financial market. A conviction narrative is an internal representation of each agent's environment that allows the agent to feel convinced enough to make decisions and feel comfortable with them, although the future outcome of that decision cannot be validly estimated probabilistically. The theoretical concept was developed to understand how decision-makers manage to act when they can have no calculable certainty about the future. But it has recently been operationalised to capture shifts in emotional sentiment in organisations and financial markets (Tuckett et al. 2014a²⁸) and to provide theoretically defined macro-indicators of market confidence (Tuckett et al. 2014b²⁹).

Of course, a narrative is influenced by the behaviour and opinions of other agents to whom any given agent is connected. Understanding how competing narratives emerge and how some percolate across a network whilst most fail is the next task in incorporating uncertainty into firm behaviour. I did set out over a decade ago a simple model of the business cycle incorporating networks in this way³⁰, which is able to account for the time and frequency domain properties of annual real GDP growth, as well as the size distribution and frequency of recessions. In this model, cycles are endogenous and arise through both uncertainty and the fact that companies operate on completely different scales.

²⁶ D Tuckett, *Minding the Markets: An Emotional Finance View of Financial Instability*. Palgrave Macmillan, 2011

²⁷ D Tuckett, 'Financial markets are markets in stories: Some possible advantages of using interviews to supplement existing economic data sources,' *Journal of Economic Dynamics and Control*, 36, 1077-1087, 2012

²⁸ D Tuckett, P Ormerod, R Smith and R Nyman, 'Macroeconomics with Human Sentient and Social Actors', Paper presented at the Economic and Social Research Council Conference on Diversity in Macroeconomics: New Perspectives from Agent-based Computational, Complexity and Behavioural Economics. 24 February 2014.

http://www.essex.ac.uk/economics/documents/19Feb2014ESRCDiversityinMacroeconomicsProgram_AliForm at.pdf

²⁹ D Tuckett, P Ormerod, R Smith and R Nyman, 'Big Data and Economic Forecasting: A Top-Down Approach Using Directed Algorithmic Text Analysis', Workshop on using Big Data for forecasting and statistics, European Central Bank 7 and 8 April 2014

³⁰ P Ormerod, 'The US business cycle: power law scaling for interacting units with complex internal structure', *Physica A*, 314, 774-785, 2002