Situational Analysis and the Concept of Equilibrium

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1. Introduction:

In his 1963 lecture at the Department of Economics at Harvard, Popper [1] defines the method of social science in the following terms ‘ the description of a concrete historical *social situation* is what corresponds in the social sciences to a statement of *initial conditions* in the natural sciences. And the *‘models’* of the theoretical social sciences are essentially descriptions of reconstructions of *typical social situations’*.

This statement is key to understanding how Popper viewed the differences between social and natural science. In both cases, he propounded a four stage process, moving from the identification of a problem, postulating a theory which might account for the phenomenon, bringing evidence to bear on this theory and finally reformulating the theory and the problem as a result.

In Popper’s view both social and natural science follow the same route, but they do so in different ways. First, there is the question of what is meant by ‘initial conditions’. Second, in social science, Popper argues that the principle of rationality is a core assumption that cannot be questioned if social science is to be possible.

The term ‘initial conditions’ is a standard term in mathematical analysis, used to describe the empirical starting point of the values of the parameters of the model (and where appropriate, the values of its variables) from which any particular solution of the model is generated. Typically, a model in the natural sciences will attempt to account for a problem in as general way as possible, and there is a wide range of potential initial conditions which can be constructed, each of which leads to an individual solution of the general model. To give a very simple example from high school algebra, suppose we postulate as our model of a particular phenomenon the quadratic equation

$$aX^2 + bX + c = 0 \qquad (1)$$

This says that the parameter a, multiplied by the variable X squared, plus the parameter b multiplied by X plus the parameter c equals zero. A particular set of initial conditions is a = 1, b = -5 and c = 6, which gives the particular solution that X is equal either to 2 or 3. Different sets of initial conditions give different solutions to the general model (1)

Unfortunately, Popper is not clear that this is what he meant by the term 'initial conditions'. Certainly, he has not always been interpreted in the mathematical sense. What appears to have happened is that confusion has arisen between the consideration of a particular social situation, or set of initial conditions in the above sense, and the consideration of a generalised, or typical, situation. Indeed, the opening quotation from Popper suggests that social scientists should proceed by looking at typical, more general, situations, rather than particular, actual historical ones. We can interpret the statement as suggesting that their models will describe these general situations and can then be applied to particular situations in order to test the general conclusion.

Economics seemed to Popper to encapsulate this approach, as it tries to construct models which are general and independent of time or any set of particular initial conditions. He argued that other social sciences would be improved by emulating it.

Unfortunately, the attempt to propound general solutions which can be applied to *any* set of initial conditions has led to serious problems for the discipline of economics and it is only by abandoning this approach that the subject can hope to make progress. In section 2, we summarise the fatal weaknesses that modern mathematical techniques have exposed in the general formulations of the basic economic model. The core model relies upon the existence of a unique equilibrium solution fostered by negative feedback. In other words, any disturbances to the system are dampened, and the system returns to its (generally unique) equilibrium point. Through the workings of the price mechanism, supply and demand are balanced in every market, regardless of the starting point, or initial conditions, of any or all of the individual markets.

In recent years, economists have been compelled to recognise the potential existence of multiple equilibria, and hence the potential importance of initial conditions and the historical situation in their mathematical sense. But the basic approach of economics is still to try to construct models which are independent of both of these. It is not hard to see why - since once the system/model can end up in different places depending on the precise initial conditions from which it starts - the ability to generalise from the model is reduced. This is particularly worrying if the discipline wants to be able to draw policy conclusions from the analysis.

Popper saw that there was a difference between an actual situation (initial conditions in the natural science sense) and a typical one, from which social science generalisations could be developed. This distinction needs to be made much clearer. It may well be that in thinking about a problem, it is permissible to have in mind a set of conditions which are thought to be typical. However, this is a proposition which needs to be tested. We need to be sure not only that the typical situation exists but also what other situations are possible if generalisation is to be justified. The sensitivity of the outcome to actual historical situations - and potential situations - also needs to be tested.

Section 3 looks at the impact on economics of Popper's assumption that social science is only possible where if rationality is assumed. We argue that this has had a deleterious impact on the development of thinking. This is not to say that Popper intended that a narrow interpretation of such rationality should be made, but this is certainly one of the results. By insisting on the *a priori* correctness of the principle of rationality, Popper failed to carry through the logic of his own analysis that the social sciences should behave as nearly as possible like the natural sciences.

In economics, rationality has been taken to mean the pursuit of self-interest and a key assumption in orthodox economics which follows from this is that the behaviour and preferences of individual agents is fixed. Agents compute rational, maximising solutions in making their choices and interact with each other indirectly through the price mechanism. However, developments in non-linear probability theory combined with advances in computer power means that this very restrictive assumption can be relaxed. Models can be built in which agents can modify their behaviour directly as a result of observing the behaviour of others.

In models of this kind, where there are more linkages between economic decisions, a completely different concept of rationality and of equilibrium is required. The system is (in general) in a state of constant change, and it is not meaningful to speak of an equilibrium point (or even points). Equilibrium is characterised by the proportion of time which the system spends in various states. Further, in such models it is not, in general, possible for individual agents to act rationally in the economic sense of the term. Even if the equations which govern the behaviour of the system are well known, it is often still not possible to carry out economically rational calculations on the future behaviour of the system because such models are by their very nature stochastic. This conclusion restores the crucial importance of the particular historical situation in deriving any actual outcome.

In our view, formal modelling of direct interaction between agents offers the potential of a powerful alliance between economists who think this way and other social scientists, for whom the idea that agents act in this way is long established. As we show below, the availability of new techniques, allied to a more rigorous approach to the assumptions made, offers the potential for a much more powerful understanding of phenomena in the social sciences and indeed a more soundly based scientific approach. Such an approach is consistent with Popper’s basic principles of analysis but also requires a re-interpretation of their application.

2. The concept of equilibrium and the general equilibrium model in economics:

It is well known that Adam Smith argued that free markets, in which everyone followed his or her own self-interest, would lead to outcomes which were to the benefit of all. It was this part of his contribution to economics which was translated into mathematics in the 'marginal revolution' of Walras and Jevons in the 1870s. The mathematics refined and sharpened the assumptions which were required for Smith's arguments to hold, and laid the foundations for the core model of economics, namely general equilibrium theory. Given these assumptions, the maths appeared to prove Smith's conclusion in a more rigorous way than was possible with purely verbal argument as well as extending his market analysis into a general one for all markets in a system. In many ways, subsequent developments in much of economic theory are no more than extensions of this original system.

But in making this formalisation, much of the richness and complexity of the original analysis was lost. Smith insisted on the importance of the institutional framework and the overall set of moral values in which free markets operate. His enormous reputation rests in the general perception of *The Wealth of Nations*, but in his own lifetime Smith was already famous for his previous work *The Theory of Moral Sentiment*. Popper's emphasis on the historical social situation and on initial conditions finds many parallels in the work of Adam Smith.

These concepts do not convert readily into mathematics - and certainly not into the maths available in the second half of the nineteenth century - and so were neglected by both Jevons and Walras and by their successors. The mathematical tool of the differential calculus which they used had had great success in the physical sciences. Both Walras and Jevons were originally trained as physicists, and it was natural to them to extend the application of the technique to economic theory.

As well as applying these techniques to individual markets, showing that the forces of supply and demand operated to produce negative feedback and a unique equilibrium, they were also applied to the operation of the market system as a whole, leading to general equilibrium.

In general equilibrium theory, the demand and supply functions for each individual agent are (in principle) specified, and the task is to find a set of values for prices which will bring about an equilibrium in the sense that the excess demand in every market is zero. In other words, that supply and demand balance everywhere.

The role of prices is not just to ensure the existence of such an equilibrium, but to guarantee its stability. In other words, if the system is at equilibrium and receives a shock, the price mechanism dampens down the impact of the shock and ensures that the system returns to equilibrium. In more modern jargon, the general equilibrium model is characterised by negative feedback: disturbances are dampened and not amplified.

An early and simple indication that the price mechanism could in principle amplify disturbances was given by the so-called cobweb theorem, sometimes known as the hog cycle. This long standing example shows how the reaction of producers to changes in price can generate instability. If all producers breed more hogs as a result of a rise in price, then in the next period there is oversupply and the price falls sharply. In reaction to this, producers cut back on the piglets and the following season there is a shortage and the price rises again. This instability is the result of the gap in time between the decision to produce and the product hitting the market. In this example, the cycle swings from glut to shortage, but it is also possible to derive examples where the instability produces an explosion or implosion. These examples are sometimes mentioned in textbooks, but are then firmly passed over. (See for example the widely used textbook by Lipsey[2]).

Such examples tended to be regarded by the economics profession as no more than curiosities. Belief in the existence of negative feedback remained, and still remains, strong. In other words, the profession holds that economies left to themselves will naturally gravitate to a position in which supply and demand balance in every market.

Over the years, very serious theoretical problems have emerged for the general equilibrium approach. As long ago as 1932, von Neumann [3] carried out a rigorous mathematical investigation of the assumptions which were required to guarantee the existence of a solution to the general equilibrium mode which makes economic sense. In other words, he investigated the circumstances in which a set of non-negative prices which balance supply and demand in all markets can be proved to exist. The economic interpretation of von Neumann's result is that a sufficient range of goods and services should be produced to ensure there are very few gaps in the availability of markets in which consumers are able to participate. For the most part, this appears to be satisfied.

But, outside of financial markets, there is a very big gap in the provision of markets which concern future events. And future events are important because individuals buy and sell in more than one period. For example, they can delay consumption or buy now to consume later. So, even given all the other assumptions of the competitive model, it is not possible to prove that a set of prices will exist which will permit demand to equal supply in all markets, without making the further assumption that there is a very large number of futures markets, transparently more than the number which exists in reality.

Even if existence can be proved, the separate problem exists of how to find the solution in practice. Walras over a century ago realised that this was a serious issue, and posited the existence of an Auctioneer. Before any trading can take place, the Auctioneer issues a set of prices - 'crié au hasard' - to all agents. These latter respond by saying how much of each commodity they would buy and sell if these prices actually obtained. Except by the purest of coincidence, this set will not be the market clearing one. The Auctioneer uses this information to update the set of prices, to which agents respond, and so on until the solution is found, when actual trading is allowed to take place at these prices.

This method of search for solutions to a system containing a large number of equations is now a familiar problem in applied mathematics and, thanks mainly to the development of computer power, we now know far more about it than even thirty years ago. But the simple example of the cobweb theorem shows that it is easy to construct circumstances in which a solution, though it exists, might never be found.

More generally, economists have begun to realise that systems of equations such as that which describes the general equilibrium model are likely to have not just one but many possible solutions. Two serious problems are raised by this. First, it provides a rationale for government intervention in the economy after all. A free market economy is unable to co-ordinate the decision as to which of the many potential equilibrium situations will actually be called into existence.

More importantly, the existence of multiple equilibria reduces dramatically the policy implications which can be drawn from the competitive model. If a unique solution exist, large changes can be analysed in this framework, since by definition the economy will always end up at its unique equilibrium. But with many solutions, it is possible to make statements only about the consequences of small changes in the locality of any particular solution. Large changes might lead to important changes in the overall nature of the new solution at which the system ends up, and free market theory is quite unable to determine what these might be..

An important theme in economic theory in the past decade or so has been to try to address both this problem and the question of what happens when small changes are made to the assumptions of the general equilibrium model, such as the one that no individual or group can exercise any influence over the prices at which goods and services are bought and sold. A recent survey by Silvestre [4] points out that neither question has been answered satisfactorily. Indeed, the work has raised further problems for the conventional theory, since even negligible violations of assumptions can often lead to outcomes far removed from the standard model of competitive equilibrium.

The above discussion of general equilibrium theory refers to a world in which time does not matter. This is perhaps the most truly remarkable aspect of the whole theoretical structure. The standard model of competitive equilibrium is timeless, and the task is to discover, if it exists, a set of prices which will ensure that all markets clear. But once the future exists, a set of prices must be found which will clear all markets today, another set must be found for tomorrow, yet another for the day after tomorrow, and so on, before any trading is allowed to take place.

The first major breakthrough in incorporating the future into the theoretical model was made by Arrow in the early 1950s. But to prove existence, Arrow had to assume that everyone holds absolutely identical and correct beliefs regarding the prices which will exist in each potential state of the world at every point in the future.

Following Arrow's work, a key research task was to try to introduce the future into the model in a more realistic way. The definitive article was written in 1968 by Radner [5], who proved existence even if different people had different beliefs about the future state of the world. But for his proof to be valid, Radner also showed that everyone needs to have access to an infinite amount of computational capacity. His own conclusion was the model of general equilibrium 'breaks down completely in the face of limits on the ability of agents to compute optimal strategies'.

In short, developments within mathematical economics itself have exposed the extremely serious shortcomings of the model of general equilibrium, dominated as it is by its timeless dimension and by negative feedback. A whole separate literature exists on empirical criticisms of the concept, of the discrepancy between theory and reality. Perhaps the most devastating is a recent comment by Arrow himself, given the major contribution which he made to the refinement of the theory. The market for labour transparently does not clear, and in most Western economies the peace-time average unemployment rate during this century has been around 5 per cent. The supply of labour is persistently higher than the demand. Arrow has stated that he regards this fact as 'an empirical refutation' of general equilibrium theory'.

The continued attachment of the economics profession to the model of general equilibrium, in the face of the devastating theoretical and practical criticism of it which exists, represents a truly remarkable case study in the sociology of science. One way in which the approach survives is through an elision of terms. Conventional economic theory is often described as being the theory of 'free markets'. In everyday English, the Western economies are often referred to as the 'market economies'. Partly because of the imprecision of language and partly encouraged by the bulk of the economics profession, it is easy to draw the conclusion that 'free market' theory is the theory of how the 'market' economies actually behave in practice.

But this is exactly what orthodox economics is not. It does not give a good account of how the Western economies behave at the overall level. But the emphasis placed on both the timeless nature of its core model and the related importance of negative feedback dampening shocks to the system are the proximate reasons why Popper's views on the importance of history and initial conditions have not taken hold. Indeed, we can say that the emergence on a mathematical basis of the core model in the second half of the nineteenth century required the elimination of precisely these aspects of the work of Adam Smith.

3. A new form of rationality

In the general equilibrium model, the tastes and preferences of individuals are fixed, and rational choices are made on this basis. But in reality, people are often influenced directly by how others behave, and alter their tastes accordingly. A neighbour buys a new car, a relative gets a video recorder, and suddenly people in the locality or family decide that they, too, want one. The scholars who established the basis for modern economics in the late Victorian era knew perfectly well that this was an important feature of the real world. But they were obliged to make the simplifying assumption that it did not exist. This was not because of stupidity - far from it - but because the mathematical tools required to analyse such processes did not then exist.

Despite the apparent mathematical sophistication of general equilibrium theory, it is not sophisticated enough to handle models in which individuals influence each others' behaviour directly. Individual agents in conventional economics only interact indirectly via the price mechanism.

In the past decade or so, advances both in non-linear probability theory and in computer power have enabled explicit models of interacting agents to be analysed. This constitutes a major potential advance in the social sciences, and allows a far more realistic description of many situations to be given. There are several aspects to this:

- initial conditions and the historical social situation are extremely important in such models

- in models of this kind, a completely different concept of equilibrium is required. The system is (in general) in a state of constant change, and it is not meaningful to speak of an equilibrium point (or even points). Equilibrium is characterised by the proportion of time which the system spends in various states

- the potential exists for an alliance between those interested in modelling interacting agents and experts in what are regarded by economists as the 'softer' social sciences such as sociology and criminology

We illustrate models of interacting agents by three examples, in each of which the new approach gives a much better account of the phenomenon than does conventional economic theory.

a) Financial Markets

The idealised world of free market theory ought to be closest to reality in financial markets. These markets operate in an almost completely unrestricted way, largely free of government intervention; information is widely and very rapidly available to all agents in the market; there are a large number of buyers and sellers; markets exist not just to buy and sell today, but contracts can be struck now to trade in a variety of complicated ways at dates in the future.

The individual buyers and sellers ought to process all the information available on an asset efficiently, and set the price accordingly. For share prices, for example, the relevant information is the flow of dividends which is expected to accrue from the ownership of shares in the company. But actual dividend payments fluctuate much less than do the associated share prices.

More generally, changes in asset prices are very distinctly more volatile than conventional theory suggests. In particular there are too many big changes. Of course, not every day sees a crash such as that of October 1987, when the value of many shares fell by 20 per cent in a single day, or more recent events in Asia when currencies lost over half their value against the dollar within a matter of days.. But large changes in individual share prices are often seen. And major currencies can, after long periods of comparative stability, change in value by large amounts very rapidly. This behaviour gives rise to statements from traders, for example, which are inexplicable by free market theory. A currency such as the dollar may be widely described as being, for example, over-valued. In other words, there is a general perception that, in this instance, the dollar is in some sense too high against other major currencies. Yet, at the same time, foreign exchange traders will continue to buy the dollar in large amounts. Such behaviour is apparently quite irrational.

Kirman [6,7] offers a deceptively simple model which provides a very neat account of 'excess' volatility in asset markets and of the associated 'irrational' behaviour. He postulates the existence of two types of behaviour which traders can follow. First, the fundamentalist, who values share prices, exchange rates and so on according to his or her perception of the fundamentals (e.g.: the flow of dividends) which determine the price. Second, the chartist, who forms a view by extrapolating, in more or less sophisticated ways, prices on the basis of their recent behaviour.

As we move from one period to the next, there are three possibilities open to the trader. To continue to behave as in the previous period. In other words, a chartist, for example, continues to be a chartist. To be influenced by the behaviour of others - and traders are bombarded with information of this - into switching from one mode to the other. And, finally, to switch behaviour by changing one's own mind independently of the behaviour of others.

A typical solution to this model, showing the proportion of traders who are acting as fundamentalists in any one period, is plotted in Figure 1.

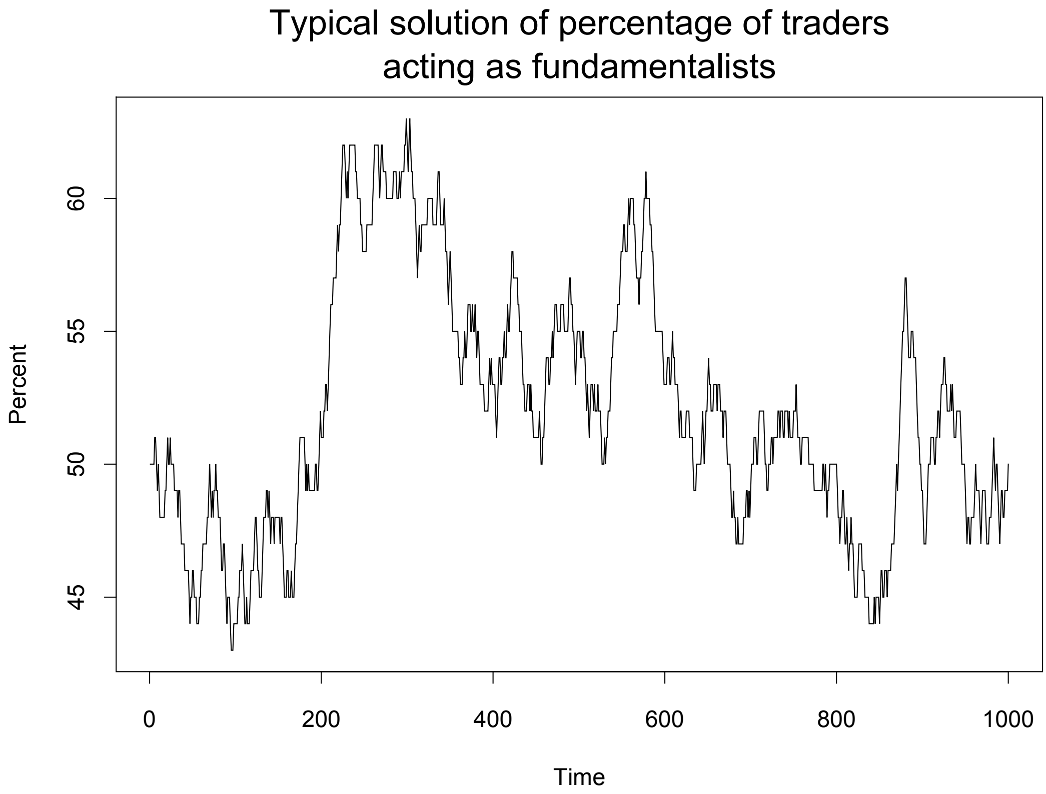

Figure 1

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Figure 1 illustrates the typical features of solutions to this apparently simple model. The proportion of traders following the different types of behaviour can remain reasonably stable for long periods, and then switch dramatically, though the proportion is never completely stable, being subject to constant change. Switches in the pattern of behaviour used to form views on asset prices leads to qualitatively similar patterns in the prices themselves. No single solution to the model will ever be identical to another, because of its probabilistic nature. But the proportion of time which the system spends at different proportions of fundamentalist/chartist behaviour will depend upon the two probabilities in the model of switching behaviour, so that equilibrium is characterised by the distribution of time the ever-changing system spends in different states. Clearly, in this model, the behaviour of any single solution to the system from any given point in time is completely dependent upon the initial conditions.

The volatility of asset prices creates serious problems for the standard explanation in economic theory of prices in financial markets. But in this context, at least, orthodoxy offers an approximate description of reality in that it, too, predicts that past information cannot be used to predict prices in a way which will generate systematic profits over time. A far more difficult issue for conventional theory arises in the choice and selection of products in areas of new technology.

b) New Technologies

In economic theory, the consumer is sovereign. He or she has access to all the relevant information, processes it efficiently, and chooses accordingly. But there are many examples of products which are technologically inferior not just surviving, but driving out of existence competitors with distinctly superior qualities. The free market sometimes chooses not the best, but the worst.

A recent example is the struggle over the VCR market between Betamax and VHS. Betamax machines were easier to operate and had a number of features which even now are not embodied in the standard model of VCR. A longer lasting illustration, so deeply embedded in our culture that it is scarcely ever noticed, is the design of the QWERTY keyboard. A controversy exists as to whether, in the final decades of the nineteenth century, it was deliberately designed to be inefficient, on the grounds that with a better ordering of the letters, keyboard operators could have typed faster than the then electronic telegraph could have transmitted. But, certainly, at various times during the last century, more efficient designs have been invented and marketed, but all have failed. The inferior technology prevails. Cowan and Gunby [8] provide examples of the prevalence of technologically inferior methods of pest control in the citrus fruit industry in Israel and in cotton in Texas.

Once the assumption is made that individuals affect each others' behaviour directly, the process by which a product can drive out a rival or, once established, be very difficult to dislodge can be understood intuitively. If by luck or a smart marketing campaign, a product gains an early lead over its rival, a self-reinforcing process can be set up. The more people who buy it, the more likely it is that those contemplating buying will also make the same choice; the more likely it is that shops will stock it more readily, and so on.

The principles underlying such processes were formalised by Arthur et.al.[9] in 1983, tackling certain problems in non-linear probability theory. An urn of infinite capacity is postulated to exist. It contains a mixture of white and black balls. A random sample of balls is removed from the urn, and various rules exist about the collection of balls which is put back in. For example, if more than half the balls removed turn out to be white, the whole sample is returned to the urn, along with an additional white ball. If more than half are black, the sample plus an extra black ball are put back. What, if anything, can we say about the proportion of white to black balls which will emerge in the urn in the long-run?

Arthur and his colleagues were able to say a great deal about what would happen under various replacement rules. Their work may seem far removed from the practical question of why, for example, one make of VCR drove out another. But it is not. In terms of two rival new products, we can think of each purchase made by an individual consumer as the equivalent of choosing a ball of one colour, and of putting it back along with another ball of the same colour into the urn. Adding the ball shifts, ever so slightly, the probability that the next ball drawn - the choice made by the next consumer about which product to buy - will be of the same kind.

In this account of the phenomenon of how inferior products can emerge as dominant in markets, the historical situation is crucial. Once an early lead is established by one competitor, whether by skill or by luck, it becomes extremely unlikely that its rival can overtake it.

c) Business cycles

The permanent existence of business cycles in capitalist economies creates serious difficulties for general equilibrium theory. Output in the Western economies is in a persistent state of change. Against the background of a positive growth trend, there are fluctuations, cycles of varying lengths. The response of conventional economists has been to posit the existence of a series of random shocks, external to the economic system, which is responsible for the observed cyclical behaviour of actual economies. Any individual shock to the economy would eventually be dampened down, and equilibrium would be restored. But it just so happens that there is an apparently endless sequence of such shocks.

The current fashion is for so-called 'real business cycle' models. All agents - companies and individuals - are assumed to behave identical ways, and to follow complicated rules which enable them to know the future with certainty. The only exception to this is the random sequence of shocks from technological change which causes business cycles. Such models, despite their apparent mathematical sophistication, are unable to replicate many of the key features of actual business cycles (see, for example, Watson [10], Cogley and Nason [11], Rotemberg and Woodford [12], and Camba-Mendez and Pearlman [13]). But their striking empirical failures have not led to their rejection by the bulk of the profession.

Ormerod and Campbell [14] offer a simple model on Keynesian lines which replicates the key properties of the post-war US business cycle far better than do real business cycle models. As a simplification, individual firms set their rate of growth of output for the next period according to the current overall state of sentiment - 'animal spirits' - about the future, and decide changes in their individual sentiment on the basis of the current rate of growth of overall output. Unlike conventional economics, when the behaviour of all agents can be summarised in the behaviour of the 'representative agent', each agent behaves differently in the face of the uncertain future. Again, the path followed by any particular solution to the model depends upon the initial conditions.

Examples are now growing of models of interacting agents which offer better accounts of economic phenomena than does conventional economic theory. And an integral aspect of such models, in their various ways, is that initial conditions and the historical situation are absolutely central to the way in which any particular solution evolves over time.

Economists like to think of their discipline as being the most mathematically sophisticated of the social sciences. But the development of the tools needed to build models of interacting agents opens up the possibility of an alliance which squeezes out conventional economics. Collaboration between researchers at the top and bottom of the mathematical hierarchy, both of whom operate firmly in the tradition of Popper's 'fundamental methodology', can give better accounts of many phenomena, and make redundant large parts of conventional economics.

4. Conclusion

We argue here that economists have shown an alarming attachment to a model that fails to take proper account of Popper's situational analysis. They have taken his injunction to generalise and forgotten about the need to test this against actual historical development. To a large extent, this - ironically - reflects the particular historical situation in which the core model of conventional economic theory was developed. Mathematical tools which had been used with great success in the physical sciences were applied to economics in the final quarter of the nineteenth century. The models constructed with them were intended to be by their very nature timeless. Regardless of the initial conditions, the free market model would converge to a unique equilibrium in which all markets cleared. And the price mechanism operated to dampen and not amplify any disturbances to this equilibrium.

During this process, much of the richness of the analysis of the early political economists was lost. The model of general equilibrium formalised Adam Smith's description of the role of the price mechanism, but eliminated his emphasis on the role of history and on the interdependence of economic agents through observing the behaviour of others.

A great deal of subsequent economic theory consists of a mathematical refinement and extensions of the model developed in the closing decades of the nineteenth century. Large parts of the economics profession are by now scarcely able to conceive of models which offer alternative approaches. This is despite the extremely powerful critiques of the theory which have emerged precisely as a result of the application of more modern and rigorous mathematics than was available a hundred years ago.

An important reason for the persistence of the core model of economic theory is the elision of meaning in the words 'free market'. The Western economies are often described as 'free market' or as 'market economies'. It is therefore easy to believe that 'free market' economic theory offers a reasonable description of such economies, even though this is very far from the truth.

A second reason for its continued strength has been the extreme difficulty of constructing rigorous alternative approaches. But the tools required for this - developments in both computing power and in non-linear probability theory - have emerged during the past ten or fifteen years.

A key assumption of conventional economics is that the tastes and preferences of individual agents are fixed. Agents maximise only their own preferences and interact with each other only indirectly through the price mechanism. This simplifying assumption about the nature of rationality was necessary for much of the period in which general equilibrium theory has existed, because even apparently simple models in which agents can alter behaviour directly in response to the behaviour of others can rapidly become analytically intractable using the types of mathematics conventionally used in economics.

Interacting agent models can now be constructed, and in this paper we give three examples, which offer more powerful accounts of important phenomena than does conventional economic theory. By their very nature, solutions to such models exhibit a strong dependence on initial conditions, on the historical situation. And they require a different concept of equilibrium. In general, such models do not have equilibrium points, but are in a constant state of change. The relevant concept of equilibrium is the proportion of time which the system spends in different states.

Research in other social sciences has recognised for a very long time that individuals respond directly, rather than only indirectly via the price mechanism, to the behaviour of others. Indeed, the discipline of sociology is almost entirely concerned with this phenomenon, of analysing individuals in society.

We believe the new tools of analysis offer the exciting potential of an alliance between economists interested in them and scholars in other social sciences. At last, a research programme based upon Popper's 'fundamental methodology' can be developed, which offers the potential of accounting for a very wide range of social and economic questions in a more powerful way than conventional economics.

References:

1. K R Popper, *The Myth of the Framework*, Routledge, London, 1994

2. R G Lipsey, *An Introduction to Positive Economics*, Weidenfeld and Nicolson, London, 1963 pp 155-159

3. J. von Neumann, 'A Model of General Economic Equilibrium', *Review of Economic Studies*, vol.13, 1945-46, English translation of 1932 paper

4. J.Silvestre, 'The Market Power Foundations of Macro-economic Policy', *Journal of Economic Literature*, vol.XXXI, March 1993

5. R.Radner, 'Competitive Equilibrium Under Uncertainty', *Econometrica*, vol.36, 1968

6. A.Kirman, 'Ants, Rationality and Recruitment', *Quarterly Journal of Economics*, February 1993

7. A.Kirman, 'The Behaviour of the Foreign Exchange Market', *Bank of England Quarterly Bulletin*, August 1995

8. R.Cowan and P.Gunby, 'Sprayed to Death: Path Dependence, Lock-in and Pest Control Strategies', *Economic Journal*, vol.106, May 1996

9. B.Arthur, Yu.M.Ermoliev and Yu.M.Kaniovskii, 'A Generalised Urn Problem and Its Applications', *Kibernetica*, January-February 1983

10. M.W.Watson, 'Measures of Fit for Calibrated Models', *Journal of Political Economy*, vol.101, no.6, pp.1011-1041, 1993

11. T.Cogley and J.M.Nason, 'Output Dynamics in Real Business Cycle Models', *American Economic Review*, vol.85, no.3, pp.492-511, 1995

12. J.J.Rotemberg and M.Woodford, 'Real Business Cycle Analysis and Forecastability', *American Economic Review*, vol.86, no.1, pp.71-89. 1996

13. G. Camba-Mendez and J Pearlman, 'Can Real Equilibrium Models Account for the Fluctuations of the UK Business Cycle?', paper presented to the ESRC Money, Macroeconomics and Finance Workshop Conference, Durham, UK, 1997, mimeo, NIESR, London

14. P.Ormerod and M.Campbell, 'On the Keynesian Micro-Foundations of Business Cycles, paper presented to the ESRC Money, Macroeconomics and Finance Workshop Conference, Durham, UK, 1997, mimeo, Post-Orthodox Economics, London