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The Economic Crisis is a Crisis for Economic Theory

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The world has recently been shaken by an upheaval in the financial sector comparable to that of 1929. These events in world financial markets have, to say the least, given economists pause for reflection. It is worth giving a schematic account of the unfolding of this crisis to see how it can be reconciled with standard economic theory or whether a serious rethinking of our theory is called for. The explanations given for the origins of the collapse of the structure are clear and convincing. Individual banks extended credit to those wishing to buy homes with little regard for the capacity of the borrowers to pay. If the unhappy borrower did not fulfill his obligations the bank recovered the home, the price of which was rising. The loans in question were distributed among banks worldwide, through instruments which packaged loans of varying quality together. This, we were told, was a good thing because it diversified the risk. However, with a weakening of the U.S. economy the number of defaulters grew and, worse, prices in the housing market no longer rose. At this point, banks started to examine their positions and to evaluate the losses and potential losses due to the "subprime" loans contained in the instruments they were holding. Many major banks found that their positions were more than delicate and began to seek ways of redressing them. However, the crucial problem was that banks did not know which of their counterparts were in trouble and thus stopped lending to other banks. The freezing of the interbank market brought the whole system to a halt since banks are constantly in need of being able to finance various transactions and habitually borrow from each other to do so.

The solution which may or may not have eliminated or reduced the problem was to inject enormous amounts of money into the system, to rescue AIG, a huge insurance company whose credit-default swaps underpinned the credit market and to essentially guarantee the bad debt. In addition, the two largest mortgage banks in the U.S were effectively nationalised. Several banks in Europe were rescued from bankruptcy and to all intents and purposes nationalised. The crisis had global consequences and an important impact on the real economy. Despite the concerted efforts of the major central banks and governments, it is far from clear how long the consequences will last.

Yet, there are signs that, at least financial markets are inclined to shrug the crisis off and to assume that we will be back on track again rather soon. There are several points worth making about this. Firstly, before macroeconomists were faced with the crisis there was a general consensus that we now understood the fundamental mechanisms of macroeconomics and that models such as the Dynamic Stochastic General Equilibrium, (DGSE) model were a good representation of the macroeconomy. The vocal and publicly audible criticisms of Krugman, Shiller and Stiglitz were dismissed as attacks based on an insufficient understanding of the powerful tools that were being employed. Secondly there has been another type of reaction, (see for example Reinhart and Rogoff (2008) which has been to point out that crises are a recurrent phenomena and that there is nothing particularly special about this one. It seems to me that this merits a reply. If the DGSE proponents have got it right, then they should be able to explain why their models do not allow for the possibility of a crisis of the sort that we are currently facing. Indeed this applies to all macroeconomic models, for if major crises are a recurrent feature of the economy then our models should incorporate this possibility.

The sketch that I have given of the onset of the crisis is a story of contagion, of interdependence, interaction, networks and trust. Yet these notions do not figure prominently in modern macroeconomic models. A first line of defence offered by economists to justify this, is that we are talking about financial markets here and that these are intrinsically different from the rest of the economy, even if the two interact. But is this really the case? Whether we are talking about models of financial markets or of the real economy our models are based on the same fundamental building blocks. The most important of these is the idea that individuals act in isolation and the only interaction between them is through the price system. All that we have to do, to deduce the behaviour of the economy at the aggregate, or

macro, level is to add up the behaviour of the individuals who make it up. In effect, the behaviour of the aggregate can be assimilated to that of an individual.

Economists are not alone in this. Both politicians and commentators use explanations such as "the market was afraid of the oncoming recession" to justify a fall in prices, or that "the newly published growth forecast made the market more optimistic", as if the market viewed the world with one mind. Yet, the idea of explaining the collective panics or collective "exuberance", to use Alan Greenspan's famous phrase, that we periodically observe, as reflecting the identical, or average behaviour of individuals who neither contact nor observe those around them, seems curious. The recent near-collapse of the world's banking system does not seem to correspond to the collective result of individual banks optimising in isolation and unconsciously coordinating on a disastrous solution. What is involved is rather a great deal of local interaction, of transmission of information, views and expectations from one actor to another. Large systems with micro characteristics of this sort are studied in physics, biology and also sociology. There, it is recognised that the system may switch rapidly from one phase to another and that this will be dependent on its internal organisation and not on some exogenous shock.

The uncomfortable thing about models of the sort of system that I am referring to, is that there is no necessary proximate cause for a sudden shift in the aggregate state, no culprits to blame and no easy remedy to prevent similar occurrences in the future. This is not the case with most of our economic models and macroeconomic models in particular. The relations between the variables are essentially fixed and the system functions at equilibrium in a very mechanical way. The only thing that may perturb the evolution of the economy is an external shock from which the economy adjusts, by assumption, to a new equilibrium. Out of equilibrium dynamics are not a central issue in economics and Gerard Debreu said explicitly that their analysis was too difficult and that was why he had never ventured in that direction[1]. So, the most interesting aspects of economics if the economy is viewed as a complex interactive and adaptive system, are absent in macroeconomic models based on the General Equilibrium view.

[1] He made this observation in an interview with E Roy Weintraub, See Weintraub().

In other words the vision of the world reflected in modern macroeconomic models leaves out aspccts of the economy which seem to be central to understanding how it functions and evolves. Indeed, the problem that intrigues many people when they first come to economics is that of explaining how the myriad of disparate individual economic activities come to be coordinated. A modern economy is composed of millions of agents who interact directly and indirectly with each other. Each of them knows a great deal about the activities they are engaged in and a lot about the people whom they interact on a regular basis. They interact intensively and directly with some individuals and less often and more indirectly with others. They have a great deal of very local information but, know much less about the behaviour of the whole economy, other than through some summary statistics. Yet, despite the fact that most of the individuals in the system are not aware of each other's existence, collectively their activities are remarkably coordinated. The questions that we should be asking, are first, how is it that all these individuals each of them with specific information and abilities organise themselves, for most of the time, in a consistent and for most of the relatively predictable way? Secondly, how is it that the system passes periodically through major upheavals ?
These problems, rather than the problem of how efficient are the states that the economy arrives at, seem to me to be the central questions for macroeconomists. While the economic system, and in particular, the financial system may give the impression that it is functioning well, from time to time it may slide into a totally different state. What I would argue is that such movements are intrinsic and not due to some exogenous shock. The movement and changes in the system do indeed, come from the, at least locally, purposeful behaviour of the individuals who make up the system. However, none of them can really be held responsible , for radical changes in the aggregate economy.

Indeed, even though the structure of the economy may be quite robust, what I would argue is that the system will evolve and may occasionally go through very large changes which would not be consistent with a static equilibrium, nor a steady state, view. Furthermore, I would suggest, for example, that what we are observing are not efficient situations in any sense. A great deal is being achieved in terms of coordination but there is almost always room for improvement in every direction, as Schumpeter (1950) firmly believed. Let me come back to the recent « credit crisis », which illustrates this well. From a situation where many dimensions of the world economy seemed to have achieved some degree of stability, we were suddenly precipitated into what has been described as the « worst crisis since 1929 ». Did this happen as the result of some major shock to the economy ? Not at all. A much more plausible

explanation is that what had happened was that norms had developed and become established. In adopting these norms the individuals were probably unconscious of their aggregate consequences. In the case of the financial crisis, the rules of the game were gently modified in the banking sector. It became acceptable to lend to people who had little chance of being able to repay their loans, it became acceptable to use more and more leveraged positions, and it became standard practice to hive off dubious loans in the form of derivatives with the argument that the risk was being « diversified ». All of this happened because the actors saw others acting in a certain way and being successful and therefore imitated their behaviour, not because they had reappraised their own portfolio and changed their estimate of its riskiness. However, this slow and almost unconscious shift was at the root of the crisis. Yet, as more and more risky loans were issued, in a world where house prices were booming nobody saw this as a real problem. The practices in question became standard procedure and this, at the very micro level, made them acceptable. Furthermore, through the dispersion of these risks through derivatives throughout the global banking sector there was seen to be no systemic threat. The individuals or banks making the decisions were not aware that their increasingly interdependent positions were generating a threat to the stability of the whole system. In fact the individual actors all felt themselves to be well protected having, in effect , insured their positions with others. There was no central mind to perceive this. The system was, indeed, as Hayek argued, organising itself, but this self-organisation, contrary to a standard and largely ideological view was not stabilising. Indeed, as I have said, it needed only a small downturn in the property market for banks to start becoming concerned about who was holding the bad risks. As soon as this happened banks became wary of lending to each other and the interbank credit market dried up. To repeat, the system froze without any specific event causing it and without the actors in the system having foreseen the collective result of their individual actions.

The situation was saved, at least temporarily, by massive injections of liquidity but not without the effective failure of some banks, and with major consequences for the real economy. But, what is important is that these were purely pragmatic measures, often orthogonal to both what models would have suggested and to ideological convictions. The only explanation given by those taking the decisions is that « in exceptional circumstances we need exceptional measures ». But it is difficult to put much confidence in measures which are taken neither on theoretical grounds nor on any well-defined policy view. What it seems to suggest is that those taking the decisions have little understanding of how the system really

functions and evolves and that the models which they or those who advise them, use, are simply too detached from reality.

How does the actual evolution of the economy compare with that of the sort of view that I believe we should develop? Firstly, the economy and the financial sector had organised itself into a highly interdependent system. Paradoxically the extensive interlocking of the components and the heavy trading of derivatives actually concealed information rather than revealing it. Thus, the system self organised its own destruction leading to a radical change in the aggregate situation. But once again, this is a story of interaction and interdepence and the breakdown of relations of trust which had emerged and not one of an external shock to a stable market.

So, the question is not to find an alternative explanation as to how the economy arrives at an equilibrium in the classic sense, it is rather, what sort of framework has it developed to achieve all of the coordination that we do observe and how does that self organisation sometimes lead to major phase changes ? There are therefore two levels on which to argue. On the one hand we would like to explain how all the agents in the economy come to coordinate their daily activities in a relatively stable fashion even though this may not correspond to an equilibrium in the standard sense. On the other hand we have to explain how a system functioning in this way, once again with no central authority to control it can suddenly evolve into a crisis ?

The evolution of macroeconomic theory

In what follows, I will briefly present the aspects of macroeconomic theory which in current models are incomplete or erroneous and try to explain how we came to develop models which have these problems. The basic argument starts with the fact that macroeconomic theory has insisted on having « sound micro-foundations » and I will argue that this has taken us down the wrong road. I will discuss the problem of aggregation and then turn to that of information. Then I will look at the « efficient markets » hypothesis, and, in particular its historical origins and why, as Alan Greenspan (2008) remarked recently, this intellectual edifice collapsed.

Finally, so as not to simply join the critical chorus, I will offer some suggestions as to what

would be a good basis for macroeconomic theory.

A more « scientific » macroeconomics and the aggregation problem

Macroeconomic theory took a major turn when it was argued that models of aggregate phenomena had to be based on « sound micro foundations ». In other words the basic building blocks have to be agents whose behaviour is based on the classical axioms of rationality which we impose on those agents in standard theory. It was no longer acceptable to study relationships between aggregate variables without individual behavioural foundations. But to take this route means examining the aggregation problem. How can we aggregate individual behaviour in such a way that the result is analytically tractable and has the sort of properties that a macroeconomist needs ? The problem of how we pass from the individual level to the aggregate level has been largely discussed in the literature and in the past those who had been brought up in the General Equilibrium tradition considered the field of macro-economics as essentially corresponding to the aggregate behaviour of a model based on rational optimising individuals. What is referred to as Walrasian macroeconomics[2] may thus, be thought of as taking individual utility or profit maximising behavour and translating it to the aggregate level. Now, for reasons which I will explain, to avoid the aggregation problem, the aggregate data is usually treated in macroeconomics, as if it were the result of one individual's decisions. This, as will soon become apparent and is well known, is not legitimate from a theoretical point of view but has not prevented macroeconomists from continuing along this path.

Those who take this route ask what meaningful relationships, between the aggregate variables of the economy can be established starting from a set of independent utility maximising individuals. But, they make the further and crucial assumption that the aggregates in question can be considered as resulting from one aggregate, or average, rational individual's choices. This has not always been the case. Many earlier economists were content to specify the relations between aggregate variables and to test them without having recourse to models of individual behaviour. It was nevertheless common practice to invoke individual decisions as a way of justifying the assumptions made about the macroeconomic relations. This explains the famous remark that "70% of Keynes' General Theory is microeconomics." Indeed, in the

[2] Whether this is appropriate or not as an appelation can be judged by looking at Donald Walker's (2005) "Walrasian Economics"

most sophisticated modern macroeconomic model referred to as the DSGE (Dynamic Stochastic General Equilibrium) synthesis the aggregation problem is not solved, just treated as if it were solved.

Where does this leave us ? Either we continue to try to reconcile aggregate behaviour with that of the standard rational individual, a hopeless task from a theoretical point of view, or we accept that the difference between individual and aggregate behaviour is fundamental and then build models which show this explicitly. Thus aggregation has to move to the centre of the stage. In this paper, I would like to argue that aggregate behavior does not correspond to that of a «rational individual » and suggest that by modelling markets or economies as complex adaptive systems we can make progress in explaining such phenomenon.

Thus the really basic issue, is that we continue in much of macroeconomic analysis to dismiss the aggregation problem and to treat economic aggregates as though they correspond to economic individuals although this is theoretically unjustified. It is this simple observation that the structure of the models, however sophisticated, that macroeconomists build, unacceptable. But what is worse is that in the anxiety to preserve the scientific foundations, macroeconomists also dismiss the questioning of the soundness of the so-called scientific foundations.Such questioning comes from behavioral economics and explicitly casts doubt on the idea that individuals do behave according to the standard « sound microfoundations ». This is very far from new, Pareto devoted a whole chapter of his Treatise on Sociology to what he described as « irrational behavior ». From Simon (1957) onwards many have suggested that individuals reason in a limited and local way. Experiments, observation, and examination of the neural processes utilised in making decisions all suggest that homo economicus is not an accurate or adequate description of human decision making.[3] But then one might reasonably ask why macroeconomists insist on their « representative agent » models.

Uniqueness, stability and the « representative agent ».

[3] For a good survey of the relevant literature see Rabin (1998).

To see what is going on suppose, for the moment that we were to accept the axioms of rationality for economic agents and wished to build our macromodels on that basis. Why would this pose a problem ? The simple answer is that even under these very restrictive assumpitons there is no guarantee that the economy would ever attain the equilibrium states which are analysed in such detail by macroeconomists. In other words the key to the problem lies in the stability of the equilibrium states. We make the usual rationality assumptions on our individuals because this enables us to prove the existence of equilibrium states which can be shown to be characterised by an efficient allocation of resources by the well-known « fundamental theorems of welfare economics ». It is often asserted that somehow an economy in equilibrium if knocked out of that state will return to it as a result of some adjustment process. Typically the Walrasian tatonnement process has been used as an example. Let us assume for a moment that we define a process which adjusts prices when they are not in equilibrium. This would not help us at all, because the fundamental problem is that the conditions which are known to guarantee the stability of such a process, cannot be obtained from assumptions on the behavior of the individuals. To be absolutely clear, what Sonnenschein (1972), Mantel (1974), and Debreu (1974) showed is that there is no hope of a general result for stability nor indeed of uniqueness of equilibria, if we wish to build a model based only on individuals who satisfy the standard assumptions on rationality.

The full force of the Sonnenschein, Mantel, and Debreu (SMD) result is often not appreciated. Without stability or uniqueness, the intrinsic interest of economic analysis based on the general equilibrium model is extremely limited. Morishima (1964) was very clear, when he said, concerning stability,

« If economists successfully devise a correct general equilibrium model, even if it can be proved to possess an equilibrium solution, should it lack the institutional backing to realise an equilibrium solution, then the equilibrium solution will amount to no more than a utopian state of affairs which bear no relation whatsoever to the real economy. »

But for macroeconomists uniqueness is also important.“Comparative statics” in which one compares one equilibrium with another one, predicated on a change in the parameters, makes no sense in the presence of multiple equilibria. Now it is clear why macroeconomists find as the usual way out of this problem the assumption of a « representative agent » and this obviously generates a unique equilibrium. However, the assumption of such an individual is open to familiar criticisms (Kirman 1992; Stoker 1995)

and recourse to this creature raises the basic problem which I have mentioned and which was encountered on the route to the
place where general equilibrium has found itself: the problem of aggregation. In fact, we know that, in general, there is no simple relation between individual and aggregate behavior, and to assume that behavior at one level can be assimilated to that at the other is simply erroneous.
It is worth noting that the SMD results show the weakness of the model but not where that weakness comes from. Nevertheless, the damage was done and many theorists realised just how unsatisfactory the basic model was. What is particularly interesting about that episode is that it was scholars of the highest reputation in mathematical economics who understood the nature of the problem and who brought the edifice down. Indeed, to this day, many economists, usually not pure theorists, continue to use the model as if the SMD results were just a formalistic objection. As a parenthesis it is just worth remarking that something that plays a key role in macroeconomics, information, was an important ingredient of the failure to solve the stability problem. The basic market model has been shown to use remarkably little information when functioning at equilibrium. But as Saari and Simon (1978) have shown, if there were a mechanism that would take a General Equilibrium, (Arrow–Debreu) economy to an equilibrium, that mechanism would require an infinite amount of information. Thus, the stability problem was basically unsolvable in the context of the general equilibrium model. To repeat, starting from individuals with standard preferences and adding them up allows one to show that there is an equilibrium but does not permit one to say how it could be attained.

With such severe drawbacks one might wonder why we have persisted with our models based on the General Equilibrium approach. The idea that the economy is essentially on an equilibrium path from which it is sometimes perturbed seems simply to be the wrong departure point. I claim that we have to start from the vision of the economy as a system of interacting agents whose actions, beliefs and decisions are constantly and mutually influenced. Such a system will self organise but there is no reason to believe that it will do so into something corresponding to our notion of an equilibrium state, and even should it happen to attain such a state, for the reasons that I have explained, it will not necessarily remain there. It seems perverse to view economic agents as isolated and only linked through an anonymous

market. As I have observed most of the explanations for the current crisis involve a very different view of the economy. Large systems of interactive individuals, molecules or particles are widely studied in other fields and their aggregate behaviour is not typically that of an average or representative member of the population. The very interaction between the individuals changes the aggregation problem and should make us aware of the fact that major changes at the aggregate level can be provoked by small events at the micro level. The fact that we have not done this seems to illustrate a basic tendency in economic theory. As arguments which undermine the models we have built arise we simply make assumptions which are not justified theoretically but which in effect make the problems disappear. We persist in clinging to the basic models and making them more mathematically sophisticated whilst overlooking their fundamental flaws. Curiously, it is only the observation of extraordinary empirical phenomena which leads to the questioning of the models and as Krugman has suggested even this may not lead to significant changes in the theory.
It is sometimes argued that the sort of evolution that we have observed in macroeconomic theory is not paralleled by the evolution of financial economics simply because the relation between theory and practice was much closer. I will now take a look at the basic hypothesis which underlies much of modern financial economics, the « efficient markets » hypothesis and suggest that we have witnessed very similar developments. Persistence with a model which is theoretically flawed and systematically contradicted by the empirical evidence. Again a quick look at the history of this concept is very revealing.

Efficient Markets

The efficient markets hypothesis which is at the heart of modern financial economics, says that all the pertinent information concerning financial assets is contained in the prices of those assets. The fundamental idea is that if there were any information other than that contained in prices some individual could profit from it by an arbitrage. In other words, if someone held information which meant that the changes in the price of some asset was predictable he would make money by using that information. Thus the conclusion is that prices must follow an unpredictable path, or what is known as a “random walk”. This idea was already developed by Bachelier in his thesis in 1900.

What is most interesting is that Bachelier's work went unnoticed for many years and then was taken up with such enthusiasm by economists. Yet, even though this work was to become the very foundation of financial market theory there were those who from the outset saw that the whole structure was unsatisfactory for exactly the reasons that I have outlined. At the time that Bachelier wrote his thesis, Henri Poincaré the great French mathematician wrote the thesis report. He clearly stated that one should not take this seriously as a way of modelling financial markets, as individuals do not act independently but are constantly influenced by others and will always be prone to herd behaviour. To cite him precisely,

« Quand des hommes sont rapprochés, ils ne se décident plus au hasard et indépendamment les uns des autres ; ils réagissent les uns sur les autres. Des causes multiples entrent en action, et elles troublent les hommes, les entraînent à droite et à gauche, mais il y a une chose qu'elles ne peuvent détruire, ce sont leurs habitudes de moutons de Panurge. Et c'est cela qui se conserve. »

Henri Poincaré La Valeur de la Science 1908

This can be translated as

« When men are close to each other, they no longer decide randomly and independently of each other, they each react to the others. Multiple causes come into play which trouble them and pull them from side to side, but there is one thing that these influences cannot destroy and that is their tendency to behave like Panurge's sheep. And it is that which is preserved ». [4]

But Poincaré's warning[5] went unheeded and, indeed interest in the area developed by Bachelier waned and Paul Levy another well known mathematician wrote in the margin of

[4] For a complete and entertaining account of this period and the origins and development of the efficient markets hypothesis, see Fox (2009)

[5] It is also worth remarking that Poincaré had a correspondence with Walras the founder of General Equilibrium theory, in which he chided the latter for his assumptions of the « infinite egoism » and « infinite farsightedness » of economic agents. The former he could accept, at a pinch, but the latter seemed, at best implausible. At the very outset of economics' journey down the path to Arrow-Debreu, Poincaré was already pointing out the difficulties, but unfortunately for economics his observations fell on deaf ears.

Bachelier's thesis, "Too much finance". So as Cootner, who was the first to give a clear definition of what constitutes the "efficient market hypothesis" says,

"Despite Bachelier's very early interest in stochastic analysis of speculative prices and Working's renewed interest in the 1920's, stock market research from this point on was very slow to develop. While professional practitioners displayed a strong and continuing interest in the stock market, it enjoyed relatively little academic attention until *after the debacle of 1929* (our italics)[34]. While such lack of attention was not absolute, it stands out very sharply in comparison with the extensive research on commodity prices and on prices of those financial instruments which came under the rubric of "money". This disinterest was compounded of many parts: the smaller role played by organized equity markets in industrial finance, a conviction that stock markets were the product of mass (irrational) psychology akin to gambling, and a shortage, among economists, of the mathematical and statistical skills necessary for effective research in this field."

Cootner (1967) p.79.

Note that it was a major crisis in the economy that rekindled interest and even then, progress was slow until economists in the 70s rediscovered Bachelier's work. But consequent upon the introduction of the first analyses based on the efficient markets hypothesis a series of papers argued that the empirical evidence was in contradiction with the theoretical predictions and that there was "excess volatility". A number of individuals showed that the distribution of returns on financial asset exhibited features such as "fat tails" and "long memory", and a particular consequence of modifying the assumptions on the underlying stochastic process was that major upheavals were much more likely than under the standard Gaussian assumptions. What is also interesting is the fact that there was a revival of interest in these "discrepancies", or put alternatively non-Gaussian phenomena, after the stock market crash of 1987. Thus it seems that significant changes, at least in financial economics have been closely related to crises. This was true despite Mandelbrot's persistent calls to turn away from the

Gaussian model and use Levy stable distributions[6]. The Gaussian distribution is, of course, a member of this family but the more general class that Mandelbrot was arguing for, does not allow for the application of central limit theorems and this seriously diminishes the analytical tractability of models built on these more general assumptions. There are two lessons here. Firstly major crises have stimulated work on the evolution of prices but secondly arguments of analytical convenience often prevail even in the face of strong empirical evidence.

It was probably for this second reason that for a long period, the efficient markets hypothesis ruled the roost. until the day when Alan Greenspan ruefully admitted before Congress that the

« the whole intellectual edifice collapsed in the summer of last year » Greenspan (2008).

Once again this was the result of a crisis rather than an internal upheaval in theory. One might well ask why this inertia in the theory and , perhaps more so in practice? The evolution of the practical use of Bachelier's theory is a remarkable illustration of how this can happen. The two most important developments in financial theory with practical applications were, arguably "optimal portfolio" theory due to Markowitz (1952) and options pricing with the development of the Black-Scholes formula, (Black and Scholes (1973). Both of these are heavily dependent on the Gaussian assumption. Thus, rather than heeding the warnings of those who argued that empirical evidence was not consistent with this assumption, the development of implementable instruments actually reinforced the dependence on the Achilles' heel of the theory. There is a depressing parallel with the evolution of economic theory. It was not only the theorists but also those who put the theory into practice who prevented a thorough reexamination of the theory. In the case of macroeconomic theory, the adoption of the DSGE model by practitioners and the investment in the calibration of those models, has meant that there was a strong resistance to questioning the value of such models. Again, the development of theory has been retarded by the putting into practice of that theory.

The Structure of Interaction: Networks

Up to this point I have tried to point out the reasons for the unhappy evolution of macroeconomics and also of financial economics. However it would be reasonable to remark

[6] He started this campaign with little success at the beginning of the '60s, see Mandelbrot (1962).

that this is all very well if one has something else to offer. In the rest of this paper I will suggest one aspect of what should be a feature of macroeconomic models within a more general recommendation. The latter is easy to formulate and I have already alluded to it. We have to base our macroeconomic models on the view that economies are systems of interacting agents and to abandon our view of the behaviour of the aggregate economy as corresponding to that of an individual. But to accept that the interaction between individuals is important requires looking at the nature and structure of that interaction.
Economies are not like many particle systems where the particles interact randomly and symmetrically with each other. The structure of interactions between individuals, firms or banks takes place through a network structure and the nature of the latter, in large part, governs the aggregate outcomes.

Networks and network analysis play a central role in many disciplines and for a long time their role in economics was ambiguous. To many social scientists the interest of networks must seem evident, since sociologists and political scientists take it for granted that network structures are at the heart of the explanation of social phenomena whereas economists have, until recently, attached less importance to them. For many economists the study of networks was limited to the analysis of the functioning of physical networks such as the railway, the telephone system or the internet for example. Yet, more recently it has been recognised that networks, are, in fact are much more fundamental and pervasive than this and this is well illustrated by Goyal's (2007) and Jackson's (2008) recent books on economic and social networks. Almost any serious consideration of economic organisation leads to the conclusion that network structures both within and between organisations are important. Let us go back for a moment to the crisis of confidence in the world economy. Here we see the role of networks. Bad risks from the American mortgage market, had been bundled with good risks into derivatives and these had diffused through the international banking system. Up to that point the financial system, thought of as a network of banks, had become larger and more connected and it was argued that the resultant diversification of risk was a stabilising influence. Yet, there was little analysis of the effect of the increasing connectivity of the network on the probability of an epidemic of negative impacts. The problem is that as risk is diversified into different instruments those who buy it lose track of the underlying asset. Thus, while the risk is diversified the information is not. When this happens, an epidemic of mistrust can develop as each bank in the network is wary of lending to another who may have inherited the risks that turned out to be bad. Worse, banks find themselves not only with

assets which may turn out to be “toxic” but the market may revise its valuation of these assets. Thus, the fact that various banks have been obliged to reassess their losses as a result of the subprime episode and its consequences was not only due to their discovering the true nature of their assets but also to their revaluation downwards by the market. The resultant losses of the banks enhance the epidemic of mistrust. It is possible that it is simply the increased connectivity of the network that has favoured the development of such an epidemic. This would be an effective counter to those who argued that the effects of shocks has been diminished by globalisation. But, in fact, the problem is more subtle than this. Propagation of information or of shocks may be more likely and the effect may be bigger in networks that are much less than fully connected. This would seem to argue against putting the blame on the increasing connectivity of the financial network and in favour of those who maintained that increasing diversification had diminished risks. What exactly is the connection between network structure and the risk of systemic collapse?

This problem was already discussed by Allen and Gale (2000). Using a network structure involving four banks, they showed that the spread of contagion depends crucially on the pattern of interconnectedness between banks. When the network is completely connected, with all banks having exposures to each other such that the amount of interbank deposits held by any bank is evenly spread over all other banks, the impact of a shock is easily absorbed. Every bank suffers a small loss and there is no contagion. By contrast, when the connectivity of the network is lower, with banks only having exposures to a few counterparties, the system is more fragile. The initial impact of a shock is concentrated amongst neighbouring banks. Once these succumb, the premature liquidation of long-term assets and the associated loss of value bring previously unaffected banks into the front line of contagion. Thus, the structure of the network heightens rather than damps the effect of a shock. Indeed, there is evidence that even in large, apparently anonymous markets, participants trade or interact with a rather small group of other traders. Thus the fact that the participants are clustered into limited groups may cause the propagation of a shock which was not particularly large at the outset. How then can we reconcile this with the fact that the existing financial network has shown itself to be remarkably fragile even though its connectivity has increased over time?

It is, in fact, other features of network structure that are important here. Degree distribution and centrality also play an important role. The first is simply the distribution of the number of connections with each node and the second is a measure of the importance of a node as a hub in the system. What we know is that while the connectivity of the global financial network

has increased remarkably in recent years, (see Nier et al. (2008)), the degree distribution has changed and has become more skewed with a few nodes having very high degree and a group of nodes becoming very central. To quote Haldane (2009) of the Bank of England, when talking about these developments in the banking network before the global financial crisis, he says,

"This evolution in the topology of the network meant that sharp discontinuities in the financial system were an accident waiting to happen. The present crisis is the materialisation of that accident. » *Haldane (2009) p. 4.*

Thus what we have observed is that a network which emerges from a particular evolution of trading relationships which are mutually advantageous can become fragile without those who participate in it realising what is going on.

The importance of this for economists is clear. Interaction and the networks through which it operates have to be analysed since, they play a large role in determining aggregate economic phenomena. This is not the place to develop an argument for network analysis in economics but some things are clear. The first step is to understand how networks whether stochastic or deterministic, influence aggregate outcomes. The next step is to understand how these networks form and if, and why, they persist. Either one can consider the evolution to be mechanistic according to some criterion of fitness or one can think of the links in the network as being consciously and strategically chosen by the individuals who constitute the nodes (see recent surveys by Jackson (2007 and 2008a).

If we are to move towards better macroeconomics we will have to incorporate explicitly the idea that the economy is a system of interacting individuals. Secondly we have to recognise that the structure of the interaction is important and then to study the consequences of the networks that emerge, for economic activity.

Indeed, understanding the structure of the networks that make up the economy is not just an intellectual exercise, it is important for very practical reasons and policy makers are coming to appreciate this. I will leave the last word on this subject to Haldane of the Bank of England,

« Deregulation swept away banking segregation and, with it, decomposability of the financial network. The upshot was a predictable lack of network robustness. That is one reason why Glass-Steagall is now back on the international policy agenda. It may be the wrong or too narrow an answer. But it asks the right question: can network structure be altered to improve network robustness? Answering that question is a mighty task for the current generation of policymakers. Using network resilience as a metric for success would help ensure it was a productive one. » *Haldane (2009).*

The general lesson

At the risk of being repetitive, let me say again that we have to acknowledge that the direct interaction between agents and the way in which that interaction is organised has fundamental consequences for aggregate economic outcomes. When agents are directly linked to each other and influence each other, the relationship between the behaviour of individuals and the behaviour of aggregate variables will be different than in the anonymous market situation in which all agents are linked to each other only through the price system. What we observe at the aggregate level will not mimic what we observe at the individual level, nor will it correspond to the behaviour of some "representative indivdual". Moreover the rationality which we attribute to economic individuals in order to justify and analyse the behaviour of aggregates may have to be modified. Thus the structure of the relationships between individuals, firms or groups is of profound importance if we are to understand aggregate or macro economic behaviour. We should, indeed, be interested in the passage from micro to macro economic behaviour, but this cannot be understood without taking into account the way in which individuals' decisions and actions are influenced by the networks of connections that link them to other agents. Furthermore, one will not, in general, be able to represent the behaviour of the aggregate as the behaviour of some average or representative individual. Just as neurologists would not think of explaining behaviour by studying the changes in a representative neuron nor should economists try to explain aggregate phenomena in this way.

This does not mean that one should not be interested in what happens at the micro level, but rather, that the passage to the aggregate level is mediated by the network structure in which individuals find themselves. Neurologists will continue to examine what happens at the

molecular level but would not argue that there is some simple passage from that level to the aggregate activity of the brain which does not involve the network of interactions between neurons.

Of course, as economists, unlike neurologists, we do not usually descend as far as the level of the neurons of economic agents, but, as interest in so-called "neuro-economics" has developed it has been argued that economic behaviour is very much determined by the network of neurons that is activated in a certain situation and that as the situation changes another network may become active. Thus even at this level it is the network structure of the neurons that is important (see Oullier et al (2008). To return to another analogy, we would not expect to be explain how much food is stored by a colony of ants by looking at the behaviour of individual ants in isolation. The organisation of the ants plays an essential role. This example raises an important point. Far from complicating things, taking direct account of interaction and the networks which organise it, actually makes life simpler for the economic theorist. This is because the reasoning and calculating capacities we need to attribute to economic agents may be substantially less than it is in standard models. Individuals operating with simple rules in a limited context may, together, generate rather sophisticated behaviour on the aggregate level. In other words, aggregation itself may be what is structuring market or group behaviour.

Conclusion

This brings me to my final point, which is to ask why we are so reluctant to envisage the different models and different tools that I have mentioned. As somebody said we went through the twentieth century developing and perfecting a model based on nineteenth century physics, perhaps in the twenty first century we could move on to a model based on twentieth century physics. But as Paul Krugman has pointed out the vested interests are strong and to ask economists to take up a new set of tools is probably asking too much. To discard equilibrium in the standared sense and to move on to study out of equilibrium dynamics is surely the right way to proceed but is perhaps too big a step for economics at the present time. To place externalities, the inluence of one person's actions on another, at the centre of the action rather than to regard them as « imperfections » in our equilibrium model is essential. But I have maintained here that if we argue that the interaction between individuals is

important then we have to specify the structure of that interaction. This means that we have to study the structure and fragility of the networks which govern the interaction between individuals and again to make this central in our analysis and not just a peripheral, albeit fascinating, topic.

Such changes are essential if we are to progress, but the inertia in the economics profession is strong and whilst the economy has shown that it is capable of sliding rapidly into a new phase, economists may well self organise to prevent this happening in the immediate future. But in the end we will move on for as Max Planck said,

« A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it »

Max Planck, A Scientific Autobiography (1949).

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