The Crisis in Economic Theory

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Abstract

This paper discusses modern macroeconomic and financial models in the light of the current crisis. Theory has been revealed to be inadequate in its explanation of the origins and the nature of the crisis, as Jean-Claude Trichet the Governor of the European Central bank and his colleagues at other central banks have indicated. Basic macroeconomic models, however sophisticated have continued to be based on the same foundations shown to be wanting in the 1970s and financial market models have continued to use the « efficient markets hypothesis » despite warnings by numerous mathematicians and economists since 1900 as to its unsound foundations. We need to construct models which may not be able to predict the timing of the onset of a crisis but will encompass the possibility of one. The most promising candidates for such models are those which view the economy as a complex adaptive system, may use some of the tools of statistical physics and do not necessarily use the standard equilibrium approach. (JEL codes: B22, D84, D85, E10, E44)
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Introduction

« When the crisis came, the serious limitations of existing economic and financial models immediately became apparent. Arbitrage broke down in many market segments, as markets froze and market participants were gripped by panic. Macro models failed to predict the crisis and seemed incapable of explaining what was happening to the economy in a convincing manner. As a policy-maker during the crisis, I found the available models of limited help. In fact, I would go further: in the face of the crisis, we felt abandoned by conventional tools. In the absence of clear guidance from existing analytical frameworks, policy-makers had to place particular reliance on our experience. Judgement and experience inevitably played a key role. « *Trichet* (2010)

There is no clearer indication of a crisis in a discipline than that those whose vocation is to use the work from that discipline, find that work of little use. At that point, either the users and, in the case of economics, this means the policy makers, have to carry on relying essentially on accumulated wisdom and experience or the discipline has to seriously rethink itself. A first reaction by many in the academic economics profession is to argue that the basic macro-economic models have fared well in « normal » times and that it is only the exceptional circumstances of a crisis that have produced difficulties. The conclusion from this sort of reasoning is that we should simply await a return to normality and then revert to the sophisticated models which we have so painstakingly developed. The alternative to this and one which I will propose in this paper, is that crises are an integral part of the evolution of economies and that we should develop models which recognise this.

What are the explanations given for the crisis ? Almost all of them involve at least one of three terms, trust or confidence, contagion and networks. Yet, none of these are an intrinsic feature of modern macroeconomic models. The first of these terms corresponds to something which is normally dealt with by behavioural economists and is not regarded as being part of the analysis of rational optimising behaviour, and yet it can be modelled in a perfectly analytical way. The second two presume some structure of the interactions between individuals or institiutions whilst in the standard model individuals participate in an isolated way in an anonymous market. One approach would be to introduce modifications to our existing models which try to incorporate some of these features that correspond to crises. Thus, models of the financial sector would be modified to incorporate the sort of contagious herd behaviour that can lead to bubbles. Macro-economic models would necessarily take into account asymmetric information, learning and the possibility of the latter leading to equilibria based on mistaken beliefs. Many such developments have taken place, and examples are the work of Allen and Gale (2009) on contagious transmission of bank difficulties, of Evans and Honkapohja (2001) on learning, of Cass and Shell (1983) on the role of sunspots or any other exogenous and irrelevant variable in shaping beliefs and that of Woodford (1990) on how people can learn rationally to harbour such beliefs. Yet, underlying all of that work is the same basic framework that is the basis for all modern macroeconomic models, that is, an equilibrium notion with isolated optimising individuals. What I will claim here is that this framework itself has to be rethought and that the failure of our macroeconomic models to provide an adequate explanation for current events is a reflection of weaknesses in the

underlying general equilibrium model and of similar weaknesses in the basic models of financial economics.

« Scientific » Foundations

« First, we have to think about how to characterise the homo economicus at the heart of any model. The atomistic, optimising agents underlying existing models do not capture behaviour during a crisis period. We need to deal better with heterogeneity across agents and the interaction among those heterogeneous agents. We need to entertain alternative motivations for economic choices. Behavioural economics draws on psychology to explain decisions made in crisis circumstances. Agent-based modelling dispenses with the optimisation assumption and allows for more complex interactions between agents. Such approaches are worthy of our attention. *Trichet* (2010)

Underlying all modern macro-economic models is the General Equilibrium model, epitomised by the Arrow-Debreu model. Most of those who had specialised in General Equilibrium theory, up until the 1970s were seriously disappointed as the fundamental difficulties with the approach. As Hildenbrand (1994) who was one of the major General Equilibrium theorists said in his book on Market Demand, (referring to the results of Sonnenschein (1973), Mantel (1976) and Debreu (1974)),

« Up to that time I had the naive illusion that the microeconomic foundations of the General Equilibrium model which I admired so much, does not only allow us to prove that the model and the concept of equilibrium are logically consistent (existence of equilibrium) but also allows us to show that the equilibrium is well determined. This illusion, or should I say this hope, was destroyed, once and for all » Hildenbrand (1994).

Some economists will, at this point, ask why this preoccupation with General Equilibrium theory which, in any event, as a subject in its own right has fallen from favour? The answer is simple, as I have just said, the General Equilibrium model, often in drastically reduced or simplified form, is the basis for almost any modern paper in macroeconomics. There is something paradoxical about the current attitude which is to use the General Equilibrium framework, in particular in macroeconomic models, whilst denying its intrinsic intellectual interest, or, more importantly, the interest of its fundamental limitations. Yet, macro-economics took up the torch and continued as if the theoretical results which has undermined General Equilibrium theory had no real importance. In fact we should have taken the warning very seriously for it is evident that many of the problems that macro-economists have run into are due to the deficiencies of the underlying theory, and worse, the way in which they have tried to eliminate those deficiencies. The basic problem is that our, now much criticised axioms of rationality guarantee neither uniqueness nor stability of equilibrium. Yet what is studied in the models are the equilibrium states. Without uniqueness we can no longer do « comparative statics » one of the standard components of the macroeconomics toolbox. Without stability we cannot know whether an economy out of equilibrium would ever reach an equilibrium. As Morishima remarked a long time ago,
,
« 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 relationship whatsoever to the real economy » Morishima (1964)

This is relevant, since macroeconomists have focused on equilibria and, in general, on steady state solutions. Yet their models do not explain how after an exogenous shock they adjust back to the old equilibrium or to a new one. What I will argue here is that a lot of the movement in the aggregate behaviour of the economy is endogenous and not at all due to exogenous shocks, so conceptually the use of « impulse response functions » to study what will happen to the economy after a shock is flawed and again, we have no reason to believe that the economy will adjust in this way. If we cannot show that under some reasonable adjustment process the economy is stable then we have to study out of equilibrium dynamics. Had we done so we would at least have envisaged the eventuality of a crisis like the current one rather than simply continuing to use the more and more mathematically sophisticated models which have been in vogue. As Solow (2009) said of the Dynamic Stochastic General Equilibrium model,

« Maybe there is in human nature a deep-seated perverse pleasure in adopting and defending a wholly counterintuitive doctrine that leaves the uninitiated peasant wondering what planet he or she is on.—Robert M Solow (2007)

As we observed in Colander et al. (2009), restricting macroeconomics to models of stable states that are perturbed by limited external shocks, but that neglect the intrinsic recurrent boom-and-bust dynamics of our economic system, is remarkable. As we know, worldwide financial and economic crises are hardly new, and they have had a tremendous impact beyond the immediate economic consequences of mass unemployment and hyperinflation in various times and places. This is even more surprising given the long academic legacy of earlier economists' study of crises, which can be found in the work of Walter Bagehot (1873), Hyman Minsky (1986), Charles Kindleberger (1989), and Axel Leijonhufvud (2000), and more recently in Reinhart and Rogoff (2010). This tradition, however, has been neglected and even suppressed. Much of the motivation for economics as an academic discipline stems from the desire to explain phenomena like unemployment, boom-andbust cycles, and financial crises, but the currently dominant theoretical models are constructed in such a way as to exclude even the possiblity of such phenomena.

Why then have we persisted with the idea that the only « scientific » models of the economy are those based on axiomatic "first principles" (basically, the building blocks of an intertemporally optimizing representative agent with completely rational expectation formation) independent of any empirical evidence ? Indeed in much of the macroeconomics and finance literature there is an almost scholastic acceptance of this view. Yet Solow (2007) has called this a "rhetorical swindle" that the "macro community has perpetrated on itself, and its students."

By now then it should be clear why, for macroeconomists,the usual way out of this problem is to maket the assumption of a 'representative agent' since this obviously generates a unique and stable equilibrium.. However, as I have said, the assumption of such an individual is open to familiar criticisms (Kirman 1992; Stoker 1995) and recourse to this device raises the basic problem which I have mentioned and which blocked progress in general equilibrium theory, the problem of aggregation. In fact, we know, as I have already pointed out, that in general, there is no simple relation between individual and aggregate behaviour, and to assume that behaviour at one level can be assimilated to that at the other is simply erroneous. This is well established in other disciplines sueh as physics and ecology but does not seem to have penetrated macroeconomics. From the point of view of basic economic theory the problem is

well illustrated by the following elementary example. From the standard rationality assumptions on individuals, it follows that each of their demand for goods satisfy the 'Weak Axiom of Revealed Preference' (WARP); that is, if in some situation, an individual chooses alternative 'x' when he could have chosen 'y' he will never choose 'y' when 'x' is available. But, unfortunately, if we sum the demands of two individuals, both of whom satisfy WARP, their aggregate demand may not satisfy it. Thus even well-behaved individuals do not, in sum, necessarily have well behaved demand and to assume therefore that the aggregate has the same characteristics as its components is simply unjustified.

Thus, by insisting on « scientific foundations » we are forced to resort to unscientific hypotheses which have no empirical or theoretical justification.

« Rational » Expectations

« We may need to consider a richer characterisation of expectation formation. Rational expectations theory has brought macroeconomic analysis a long way over the past four decades. But there is a clear need to re-examine this assumption. Very encouraging work is under way on new concepts, such as learning and rational inattention…we need to better integrate the crucial role played by the financial system into our macroeconomic models. One approach appends a financial sector to the existing framework, but more far-reaching amendments may be required. In particular, dealing with the non-linear behaviour of the financial system will be important, so as to account for the pro-cyclical build up of leverage and vulnerabilities. » *Trichet* (2010)

At the outset, I asserted that one of the basic problems with macroeconomic models was the failure to integrate the financial sector into the model and as Trichet asserts this has been an important lack when it came to explaining the phenomena of the last few years. What I would like to argue here is that there is a link between macroeconomic models and the standard models of financial economics and this link is the Achilles' heel of both. The link in question is that of expectations. Once we introduce, as is obviously necessary, uncertainty into the system, then we are obliged to deal with the expectations of the actors in the economy. As Lucas (1995) explains,

« The prevailing strategy for macroeconomic modeling in the early 1960s held that the individual or sectoral models arising out of this intertemporal theorizing could then simply be combined in a single model. But models of individual decisions over time necessarily involve expected future prices. . . . However, . . . [aggregate] models assembled from such individual components implied behavior of actual prices. . . that bore no relation to, and were in general grossly inconsistent with, the price expectations that the theory imputed to individual agents ». (Lucas, 1995, pp. 254–55),

The elegant solution to this in macroeconomics was to close the model by assuming that agents have « rational expectations ». That is, by assumption, agents have expectations about future prices or states of the world which correspond to the « true » probability distribution of those events. But this is an assumption. How the economy would arrive at such a state is not specified. One can think of rational expectations as being an essentially theoretical exercise in the sense that one can solve for an equilibrium by asking what expectations would individuals need to have for this situation to be an equilibrium ? This does not even pretend to ask the question as to why they should arrive at those preferences. But, before even wondering about

the dynamic process which might lead to such a consistent solution one might also ask, what is the evidence that people do actually have « rational expectations ». This is, of course, difficult to evaluate, but ,at least a first step, is to survey expectations and ask to what extent people hold common ideas about the future. To what extent, does the empirical evidence bear out the idea that participants in financial markets have rational expectations, and more importantly, to what extent do people seem to act consistently with what they forecast ? To take just one example from a considerable literature on this subject, Shiller (1989) notes that « just before the U.S. stock market crash of October 1987, 84% of institutional investors thought that the market was overpriced; 78% of them thought that this belief was shared by the rest of investors and, yet, 93% of them were net buyers. » Robert Shiller (1989)

Thus although there was considerable agreement about the evolution of share prices the actions taken did not seem to be consistent with those expectations. In other words, it does not seem, at least in this case, that agents were reacting rationally to their conditional expectations.

Here, a word of warning is in order. If agents have different information then their expectations conditional on that information may differ from individual to individual. As I will point out later the well-known « efficient markets » hypothesis should rapidly eliminate such differences since by acting on their expectations and hence on their information individuals will have an effect on prices which will be visible and their information will be conveyed to the other participants in the market. But what if agents have access to a common source of information and that, itself, is biased ? This is the point of view taken by Barnett (2011) and is already known as the *Barnett critique.*

The Barnett Critique
There are therefore two approaches to analysing rational expectations. One of which is to suggest, as I do, that the whole approach is fundamentally unsound and the other is to suggest that people do act rationally on their expectations but that the information on which they condition their expectations is wrong or incomplete. Barnett (2011) takes the latter point of view and argues forcefully that the data on money supply furnished by central banks is fundamentally flawed. He points out that policy based on such data will not have the effects intended and that if households, firms and banks base their choices and form their expectations on the basis of this data the economy will be doomed to deviate from equilibrium. Thus Barnett adopts a different stance from that which I take in this paper. He does not question existing economic theory but rather suggests a different explanation for fluctuations and business cycles. What Barnett argues is that rational economic agents have incomplete information about the economy, because of what he describes as « the unprofessionally produced data by the central bank ». What he claims and gives evidence for is that data problems may have caused the subprime financial crisis and the global recession. One could also think of Barnett as implicitly proposing a new business cycle theory, based on the idea that misperceptions as to the money supply due to low quality data provided by central banks are the source of business fluctuations. This theory would be in line with earlier literature on misperceptions and might be thought of as linked to the work of Michael Woodford (1990) on « learning to believe in sunspots ». In that model, agents coordinated on an unfounded view that the evolution of the market was correlated with an exogenous process such as sunspots. In Barnett's vision the agents would be coordinating on the wrong data furnished by the cenral banks. To push this argument a little further, Barnett points out that the period during which the Federal Reserve has been accused of having too loose a monetary policy was, in fact, if correctly documented, a period of monetary tightening. Thus agents

reacted, according to him, rationally but to the wrong data. They conditioned their expectations on the wrong information set.

Barnett gives a simple example. As he explains, leverage on Wall Street increased to 35:1 prior to the recent Great Recession, but never previously in US history had exceeded 30:1. He argues that since leverage was lower during the 1920s for many Wall Street firms, some financial firms survived the Great Depression of the 1930s but did not survive the recent financial crisis. But the important question is why was leverage lower in the 1920s? As he says there was far less regulation during the 1920s than prior to the Great Recession, and margin requirements were much lower than at the present time. With very low margin requirements and very little regulation, financial firms could, he argues, easily have matched or exceeded the more recent 35:1 leverage. He does not accept the argument that people were simply more risk averse at the time. Furthermore he wishes to keep the hypothesis that people are rational and act optimally given their information. Therefore, he argues, people must have had the wrong information. Now, it would be difficult to refute the convincing evidence as to the poor information that has been circulating. However, other things are at work which mean that we are forced to go beyond his explanation.

Back to Rational Expectations

One very plausible explanation of rational expectations is that they are the result of a learning process. Thus, individuals learn from previous experience to form correct expectations. This idea goes back a long way and was advocated by Frydman and Phelps, (1983) who gave an important early impetus to work on explicit models of the way in which economic agents learn about the laws of motion of the variables that they need to forecast and the consequences of such learning for macroeconomic dynamics. They were among the first to argue that individual rationality alone provides no guarantee of the coordination of beliefs that is assumed in a rational expectations equilibrium and stress the need for a model of learning as an element of a convincing model of aggregate dynamics. By the 1990s, this point of view was widely adopted even by leading proponents of what had become standard macroeconomics such as Sargent, (1993). Since then work on the macroeconomic consequences of learning dynamics has become one of the major developments in modern macroeconomics, even though it often does not sit comfortably with a more steady state view of the economy.

The importance of learning is clearly recognised by policy makers. For example, Mervyn King the governor of the Bank of England points out that central banks are also faced with the problem of learning about a changing world. As he says,

« Any monetary policy rule that is judged to be optimal today is likely to be superseded by a new and improved version tomorrow. . . . So learning about changes in the structure of the economy lies at the heart of the daily work of central banks. To describe monetary policy in terms of a constant rule derived from a known model of the economy is to ignore this process of learning. (King, 2005, pp. 8–10).

One of the strongest objections to the rational expectations approach, and also to the Barnett critique, or to the convergent learning process comes from econometrics. For what is essential in the rational expectations approach is that individuals take their decision on the basis of their expectations conditioned on their information. However, for this to be valid, it should be the case that their conditional expectations should be the best predictor available to them. Yet,

as Hendry and Mizon (2010) point out, this will not be the case if the process which governs the evolution of the economy is subject to « structural breaks » or, put alternatively, if the distribution of the changes in the variables of the economy which the agents are trying to forecast varies over time.

They argue that the financial crisis leading to the recessions round the world during 2007–2010 is simply the most recent example of a structural break. As they say,

« Such changes, or more precisely structural breaks, not only lead to difficulties in economic forecasting (see Clements and Hendry, 2001), but also in the formulation of economic models of the economy. The latter is not simply a matter of modeling in the face of structural breaks, but confronts a deeper problem. The mathematical derivations of dynamic stochastic general equilibrium (DSGE) models and new Keynesian Phillips curves (NKPCs), both of which incorporate 'rational expectations', fail to recognize that when there are unanticipated changes, conditional expectations are neither unbiased nor minimum mean-squared error (MMSE) predictors, and that better predictors can be provided by robust devices. As a consequence, the law of iterated expectations then does not hold as an inter-temporal relation unless all distributional shifts are perfectly anticipated by all economic agents, a possibility contradicted by the recent financial crisis. Further, given the prevalence of such changes, learning about the post-change scenario is both difficult, and itself generates further non-stationarities ».

Hendry and Mizon, (2010).

Where does this leave us ? According to Frydman and Goldberg (2007) the problem arises from the logical inconsistency in trying to develop a fully determined model of economic change. What they argue for is a new approach that represents individual behaviour and aggregate outcomes mathematically, but which, at the same time, refrains from fully prespecifying economic change. They propose what they call Imperfect Knowledge Economics. They argue that in a continually changing world it is unreasonable to imbed individuals in a fully determined model whether the individuals in question are as described by behavioural or more orthodox economics. They cite Mervyn King (2005) again whcn he said,

 "Our understanding of the economy is incomplete and constantly evolving, sometimes in small steps, sometimes in big leaps." King (2005)

As an illustration of how individuals have changing perceptions of the enviroment they function in they note the following observation. individuals update their information sets more frequently in countries with higher inflation. A possible explanation is provided by Sims' theory of » Rational Inattention ». Sims (2003, 2006) which models economic agents as having a limited capacity to absorb information. They therefore need to decide how much to pay attention and which pieces of news to look at. Sims (2003, 2006) argues that when inflation is high, agents will pay more attention to new information as their opportunity cost of being inattentive is significantly higher during these periods. Even with this « rational » underpinning the idea that individuals act in a fully rational way, with a fixed and complete picture of their environment is unconvincing.

All of this seems to suggest that we have to move away from the rational expectations approach and to find models which allow for misperceptions and for the fact that individuals cannot fully understand the world in which they operate. As Bernanke (2010) said,

« I just think it is not realistic to think that human beings can fully anticipate all possible interactions and complex developments. The best approach for dealing with this uncertainty is to make sure that the system is fundamentally resilient and that we have as many fail-safes and back-up arrangements as possible »

Bernanke, Interview with the IHT May 17th 2010

A last remark is in order before finishing the discussion on the weaknesses of current macoeconomic general equilbrium models. One of the major problems with these models is that they are, as their name suggests, equilibrium models and it is argued that they are only periodically disturbed by some exogenous shocks. Since it is hard to imagine what sort of unpredictable random shocks can hit an economy they are often and conveniently assimilated to "technological shocks" though, as Stiglitz once remarked, the notion of a negative technological shock is a little odd. Do entrepreneurs have occasional buts of amnesia? This is far from a new issue. In the thirties Frisch and Schumpeter had prolonged discussions about the nature of economic dynamics. Frisch was interested in how the economy adjusted after these external shocks, in much the same way as modern economists analyse "impulse response" functions. However, Schumpeter insisted on the idea that the shocks in question were internal to the system and an intrinsic feature of the functioning of the economy. A detailed and very enlightening discussion of this debate and the attitudes of the economists and econometricians of that period can be found in Louca (2007). It may be the time to return to the more Schumpeterian view that change is inherent in the system and that we are not dealing with equilibrium paths as is so commonly assumed.

To conclude this part of the argument it seems that the standard underpinnings of our theory are based on a General Equilibrium model which is flawed from many points of view. Yet for many economists the current crisis was largely financial rather than real and it was only ex post that the real consequences were felt. Thus what is important in a second step is to see to what extent the theory underlying financial economics was also flawed.

The foundations of financial economics

The foundations of modern financial economics are usually traced back to the work of Bachelier who, in his thesis, developed the theoretical basis for the idea that the prices of a financial asset must follow a random walk. The latter notion although attributed to others such as Einstein and some of Bachelier's predecessors, can reasonably, as Kolmogorov said, be ascribed to Bachelier himself. Bachelier argued that the changes in the price of a financial asset should be random, with mean zero and by a limit argument for the sum of random variables he argued that the distribution should be Gaussian. This idea was the foundation for later developments such as Markowitz' optimal portfolio theory and for the Black Scholes formula for pricing options, and it can reasonably be regarded as the basis for the modern theory of finance. Indeed, the « efficient markets hypothesis » which asserts that all relevant information on assets is contained in the market prices for those assets is directly derived from Bachelier's ideas. It is, of course, at the heart of the arguments for letting financial markets operate without interference. But, just as was the case with General Equilibrium theory and its underlying assumptions on individual rationality and on aggregation there was no shortage of warnings as to the validity of the theory.

For example, Mandelbrot started a campaign with little success at the beginning of the 1960s;

(see Mandelbrot (1962)) and argued fiercely againt Bachelier's theory and pointed out that there was a mass of empirical evidence contradicting the basic assumptions. Although his voice went more or less unheeded , he was but the last of a distinguished line of critics. Poincaré in his report on Bachelier's thesis said that the assumption that underlay the thesis, that individuals, act independently on their information was manifestly false. As he pointed out, humans have a natural tendency to herd and this would never change. As a result Bachelier's work could not accurately depict the evolution of the prices of financial assets. Keynes (1912) himself reviewed Bachelier's work and concluded that the hypotheses were unreasonable. Mathematicians such as Levy, and Kolmogorov, (though somewhat more sympathetic to Bachelier's ideas) pointed out the unreasonableness of Bachelier's ideas. Mandelbrot continued the battle and as late as 2009 he was still criticising the assumption of the continuity of the price change process which is a fundamental feature of modern mathematical finance.

It is worth noting that it has systematically been the development of major crises in the economy that have rekindled interest in the foundations of mathematical finance. After the great depression of 1929 modern finance started to develop, and of course, according to Mandelbrot on the wrong track. But even then progress was slow until economists in the 1970s rediscovered Bachelier's work and began to exploit his ideas. This led to the « efficient markets » hypothesis which essentially says that all relevant information concerning an asset is contained in its price. But, consequent upon the introduction of the first analyses based on this hypothesis, a series of papers argued that the empirical evidence was in contradiction with the theoretical predictions and that there was 'excess volatility' (see e.g. Leroy and Porter (1981) and Shiller (1981).

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 Bachelier's Gaussian assumptions which had become commonly accepted. Periodically, financial economists have paid attention to the discrepancies pointed out by Mandelbrot and others, but usually the interest died out quite rapidly. What is also interesting is the fact that there was a revival of interest in Mandelbrot's 'discrepancies', or put alternatively non-Gaussian phenomena, after the stock market crash of 1987, another of the highly improbable events according to standard theory. Thus, it seems that the need felt for significant changes, at least in financial economics have been closely related to those crises which the theory suggests should not recur with such frequency. Yet, the persistent calls to turn away from the Gaussian model, were largely ignored .

Mandelbrot himself together with a small number of other critics of mathematical finance proposed the use of Levy stable distributions as a model for price change distributions. The Gaussian distribution is, of course, a member of this family but the more general class does not allow for the application of central limit theorems and this seriously diminishes the analytical tractability of models built on more general assumptions. What is particularly remarkable is that Eugene Fama who might be considered as the high priest of the efficient markets hypothesis had, as his thesis adviser, Benoit Mandelbrot! Indeed, Mandelbrot lamented the fact that his best students decided to overlook the basic weaknesses of the Gaussian foundations of financial theory and became more interested in making money than in seeking the truth. Perhaps even more striking is that Fama himself published a paper in 1965 showing that, without the Gaussian assumption, diversification can actually increase risk. Yet this argument has been put to one side in the later financial literature. Many of

Mandelbrot's criticisms are developed in Mandelbrot and Hudson (2004) and he never wavered in his contempt for the standard approach. He must have savoured the moment when Alan Greenspan (2008) declared before a House of Representatives committee, talking of the efficient markets hypothesis, « The whole intellectual edifice collapsed » !

To see what was at the origin of this debacle we simply need to go back to Bachelier's original question, why do stock prices change? The answer he gave and which is embedde in the theory of efficient markets, is that prices move because some new piece of information becomes available, leading to a revision of the expectations of market participants. But what is the empirical evidence for this ? As Joulin et al. (2008) point our, if this picture was correct, and in the absence of "noise traders", the price should essentially be constant between two news items, and move suddenly around the release time of the news. If there were noise traders who, as their name suggests trade randomly, they should add high frequency mean-reverting noise between news, that should not contribute to the long term volatility of the price. The arrival of news should be the main determinant of price volatility. There are, however, various pieces of evidence suggesting that this picture is incorrect. Volatility is much too high to be explained only by changes in fundamentals The volatility process itself is random, with highly non-trivial clustering and long-memory properties (for a survey, see Teyssiere and Kirman (2006)). As Joulin et al (2008) explain, many of these properties look very similar to endogenous noise generated by complex, non-linear systems with feedback, such as turbulent flows. On liquid stocks, there is in fact little sign of high frequency mean reversion that one could attribute to noise traders. Thus the existence of « excess volatility » cannot be attributed to random trading. It rather appears that most of the volatility arises from trading itself, through the very impact of trades on prices. This confirms the earlier results of Cutler, Poterba and Summers (1989).

More recently, it has been found by Bouchaud et al. (2004), using high frequency data to decompose the volatility into an impact component and a news component, that the former is dominant. Joulin et al. (2008) confirm this conclusion directly, using different news occurrences synchronized with price time series. Their main result is indeed that most large jumps are not related to any broadcast news, even if they extend the notion of 'news' to a collective market or sector jump. They also find that the volatility pattern around jumps and around news is quite different, confirming that these are distinct market phenomena.
This suggests that the mechanism governing the formation of prices in financial market is much more subtle than that contained in most standard equilibrium models. If we look at markets run on an order book basis a number of features emerge. For example Bouchaud et al. (2009) show that order flow turns out to be a highly persistent, long memory process, both in sign and volume. This reflects the fact that even on very liquid markets, the revealed liquidity is in fact extremely small (typically 0.001% of the market capitalisaion of a stock). This is, he explains, due to the fact that arge orders to buy or sell can only be traded incrementally, over periods of time as long as months. This is precisely because those doing the trading wish to avoid their trades having an impact on the current market price. But this has an important consequence for models which use a temporary equilibrium approach since with such a feature, prices cannot be instantaneously in equilibrium, and cannot immediately reflect all available information. There is, as Bouchaud et al. (2009) point out, nearly always a substantial offset between latent offer and latent demand that only slowly gets incorporated in prices.

This means that to be compatible with market efficiency, price formation, the dynamics of liquidity, and the nature of impact would be very different than they prove to be in reality.

Perhaps even more important, the distinction between "informed" trades and "uninformed" trades cannot be made on anonymous, electronic markets. This in turn means that the average impact of all trades must be the same, which means that impact must have a mechanical effect, ceteris paribus, the appearance of an extra buyer (seller) must on average move the price up (down). But this undermines an essential feature of the efficient markets hypothesis which is that price movements reveal the information available to the trader in question.

Evidence from previous crashes

Since bubbles and crashes are not features of standard models it is worth looking briefly at a number that did occur despite the refusal of theory to acknowledge their existence and Reinhart and Rogoff (2010) have amassed an enormous amount of empirical evidence on this subject. The defects of the standard model of financial markets became apparent with the 1987 stock market crash. This was followed by the bursting of the internet bubble, the Asian currency crisis, the Russian government bond default that was, at least in part, responsible for the failure of the hedge fund Long-Term Capital Management. But what is interesting is, as Lewis (2008) points out, is that none of them, it turned out, had a lasting impact on the U.S. or international economy. However, the 1987 crash was the beginning of a new era of such events since it had, as its origin, the endogenous evolution of the markets and was not attributable to some real perceived economic problems. It was a result of the new complexity of financial markets, and as I wish to argue here was a feature of the self organisation of this complex system. A closer look reveals how the self interested and rational behaviour of investors together with the appearance of new financial instruments led to a collapse in the market..

At the origin of the collapse was portfolio insurance, invented by Hayne Leland and a colleague at the University of California at Berkeley. Portfolio insurance is based solidly on the Black-Scholes options-pricing model. The model is based on the assumption that a trader can essentially remove the risk in the market by taking a short position and increasing that position as the market falls, thus protecting against losses, no matter how steep. Nearly every investment plan uses Black-Scholes as its guiding principle. Thus, in principle, agents can create put options[1] for themselves, cheaply, by shorting[2] the stock market index as it falls, and thus, in theory, be largely free of all market risk.

However, this idea ignores an essential fact, that when a market is crashing and no one is willing to buy, it's impossible to sell short. If all the investors are trying to sell their assets as a market falls, they create the very disaster they are seeking to avoid. Their desire to sell drives the market lower, triggering an even greater desire supply of the assets on the market and, ultimately, risks driving the market into an unending downward spiral. It was perhaps symptomatic of the failure of the theory that the biggest portfolio insurance firm, Leland O'Brien Rubinstein Associates (created and owned by the same finance professors who invented portfolio insurance), tried to sell as the market crashed and was unable to do so.

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[1] An option contract giving the owner the right, but not the obligation, to sell a specified amount of an underlying security at a specified price within a specified time.
[2] Short trading allows investors to borrow and sell a security and buy it back later at a lower price, making a profit on the price decline.

The theory behind the practices that had led to the crash however, survived and this has been characteristic of both financial and economic theory. Once a theory becomes sufficiently mathematically sophisticated it takes on a life of its own. Thus theory was largely unaffected by the 1987 crash but it did have empirical consequences. The price of insurance rose reflecting the fact that there was a general recognition that what were previously thought of as « seven standard deviation events » were happening much more frequently than that and secondly that it was not logically possible to protect a position when everyone was on the same side of the market. But, perhaps most interesting of all is that the active participants in the market have developed a very sceptical attitude to the practices that they used in the past and to the theory underlying them. Lewis (2008) gives the following revealing quote>

"No one believes the original assumptions anymore," says John Seo, who co-manages Fermat Capital, a $2 billion-plus hedge fund that invests in catastrophe bonds—essentially bonds with put options that are triggered by such natural catastrophes as hurricanes and earthquakes. "It's hard to believe that anyone—yes, including me—ever believed it. It's like trying to replicate a fire-insurance policy by dynamically increasing or decreasing your coverage as fire conditions wax and wane. One day, bam, your house is on fire, and you call for more coverage?" *Lewis* (2008)

As Lewis observes what is interesting here is that the theory underlying insurance against a financial panic failed in the face of just such a panic.Yet the same theory which underlies portfolio insurance underlies the justification for the creation of derivatives. At the end of 2006, according to the Bank for International Settlements, there were $415 trillion in derivatives—that is, $415 trillion in securities for which there is no completely satisfactory pricing model since, presumably, they are still priced using some version of Black-Scholes. To quote the same fund manager again,

 "The model created markets," Seo says. "Markets follow models. So these markets spring up, and the people in them figure out that, at least for some of it, Black-Scholes doesn't work. For certain kinds of risk—the risk of rare, extreme events—the model is not just wrong. It's very wrong. But the only reason these markets sprang up in the first place was the supposition that Black-Scholes could price these things fairly." *Lewis* (2008)

It was precisely this that made Warren Buffet say as early as 2003 that.

« In our view,however, derivatives are financial weapons of mass destruction, carrying dangers that, while now latent, are potentially lethal. » *Warren Buffet* (2003)

Thus, there has been widespread recognition by practitioners and central bankers that the theory of finance has been found wanting. Yet there is still not much evidence that theory has reacted to this situation. Given this it is interesting to examine the way in which the financial crisis which led to the current global crisis developed and where what happens seems to be in contradiction with what theory suggests.

The unfolding of the financial crisis.

An essential feature of the origin of the global financial crisis was the collapse of the U.S. sub-prime mortgage market following on from a substantial increase in the number of defaults by subprime borrowers with adjustable rate mortgages. Subprime mortgages are loans made to borrowers with weak credit scores. Most of these mortgages, which were structured with very low initial monthly payments, originated in 2005 and 2006 when lenders significantly relaxed underwriting standards. This was a classic example of contagious behaviour between

banks, in which the fact that competitors were behaving in one way and that seeming to be profitable led others to follow suit. However, the profitability of this behaviour resided in the fact that house prices were rising and furthermore there was political pressure to make it easier for everyone to own his home. When real estate prices started falling in 2007 it became difficult for subprime homeowners to refinance before they were faced with higher monthly payments, and since their homes were now worth less than the amount that they had borrowed, (they had « negative equity »), many defaulted. Defaults in U.S. mortgages reached record levels in the second quarter of 2007, forcing a large number of subprime mortgage lenders to shut down or file for bankruptcy. The consequences of this spread quickly throughout the financial markets. Securities backed by subprime mortgages—typically collateralized debt obligations (CDOs) decreased rapidly in value, leading to losses for investors, including commercial banks, pension funds, mutual funds, insurance companies and hedge funds. In a few cases, highly leveraged hedge funds were forced to close when they were unable to meet margin calls. This, of course, leads to another explanation of the magnitude of the collapse the extent of leverage. This has led to an extensive discussion as to the extent to which leverage should be controlled and leverage also figured prominently in Barnett's work mentioned previously. John Geneakopolous (2009) developed what he referred to as the theory of the « leverage cycle » and argued that a major contributor to the crisis was the effect of increased leverage, which, as he explains drove prices higher.

As of the end of December 2010 total writedowns, had reached $1.314 trillion, In addition to losses stemming from CDOs and other mortgage-backed securities, companies were also forced to write down investments in mortgage lenders, hedge funds, bond insurers which were affected or even driven out of business by the subprime mortgage crisis. Although subprime mortgage defaults were largely a U.S. phenomenon, the financial impact has been global. Nearly 60 percent of the companies reporting writedowns are based outside the U.S. The impact of the write downs was made more severe by the fact that banks became unwilling to lend to each other, fearing that their partners might be in solvency difficulties due to their exposure to the risks which were now revealing themselves. The only short term solution ws the massive injection of liquidity into the system which prevented the market from seizing up completely. What are the lessons for economists from this ?

Perhaps the first is that there was a breakdown of trust or confidence between banks. Trust can be characterised in economic models by relating the probability of trading with a partner to the profitability of trading with that partner in the past. This sort of reinforcement learning is a standard feature of many models in economics (see e.g. Roth and Erev (1995)). One important feature of this type of learning is that it is dynamically asymmetric in that the loss of reputation and corresponding trust is much more rapid than its accumulation, a characteristic which is related to prospect theory, (see Kahneman and Tversky (1979). This is of interest in explaining the evolution of the current crisis since the confidence in trading partners which had been built up over a long period was rapidly eroded. Moreover, one of the most striking features of the crisis was the importance of the network linking the banks and, at the international level, linking various countries financial systems.

Networks

In this paper I argue that the interaction between individuals and between institutions is an important feature of economies. We have therefore to understand the structure of those interactions and it is well known from network theory that certain network structures are much more vulnerable than others. Many of the difficulties in the financial crisis stemmed

from the collapse of bilateral arrangements. For example, credit default is a feature of a bilateral relationship and therefore who is lending to whom, that is the network of lending relationships, is an important factor in determining what the impact of such a default will be. However, the major force behind the development of derivatives was the desire to diminish this sort of mutual dependence and to spread, or diversify, the risk. Thus, it was argued that the risk facing any individual investor was diminished as the links between agents became diluted and more widespread. The more connected networks were, it was argued, the less risk there was and this was also taken to mean that systemic risk was reduced. Networks and their impact have only recently become an accepted feature of economic models, (see Jackson (2009) or Goyal(2007) for surveys. Yet, it is becoming increasingly recognised that the network of relationships in economies can have an important impact on aggregate behaviour.

As an example, the global dimension of the current crisis is related to the increased connectivity of our already highly interconnected financial system. As I have said, these sort of aspects have been largely ignored by academic economics. But they are far from having been ignored by central banks and the current preoccupation with systemic risk is linked to the growing appreciation of the importance of financial networks and their structure. The role of the evolution of the interactions and connections between actors such as the changes in the network structure of the financial industry brought about by deregulation and introduction of new structured products is not represented in macroeconomic models. Nor has much of the work on contagion and herding behavior (see Banerjee 1992 and Chamley 2002), which is closely connected to the network structure of the economy, been incorporated into macroeconomic analysis.

In order to understand why the structure of the network is important it is worth going back to the international financial network. Figures 1 to 3 show the evolution of the international financial network from 1985 to 2005.
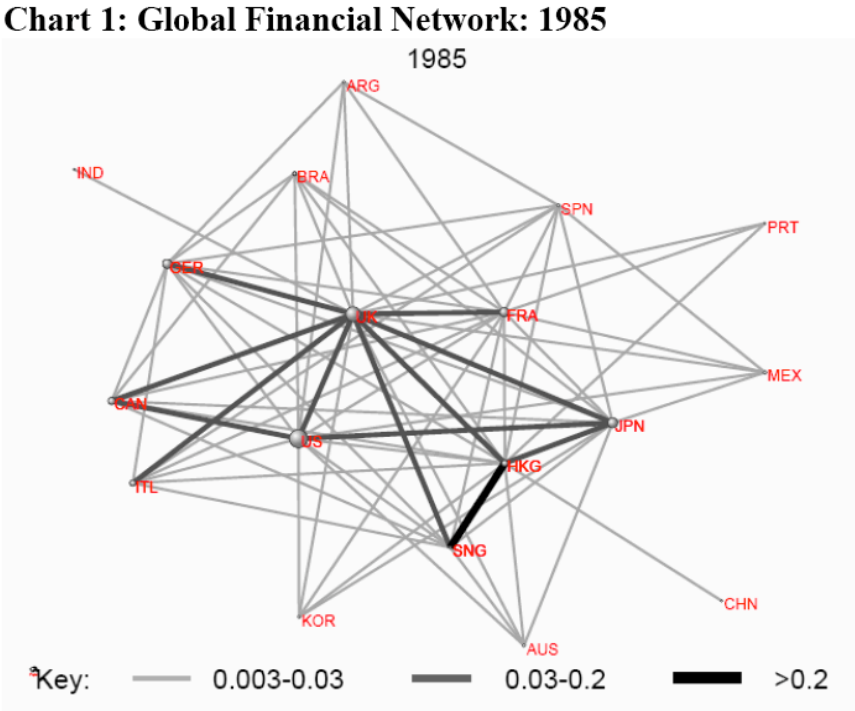
Chart 1: Global Financial Network: 1985

Figure I (source Haldane (2009)) The Global Financial Network in 1985
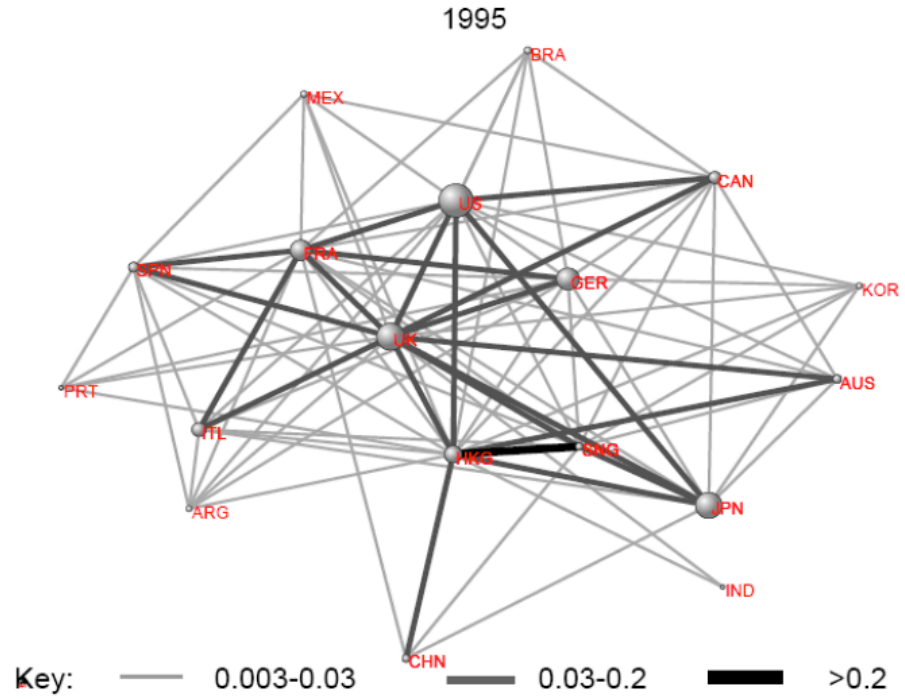
Chart 2: Global Financial Network: 1995

Figure 2 (source Haldane (2009)) The Global Financial Network in 1995
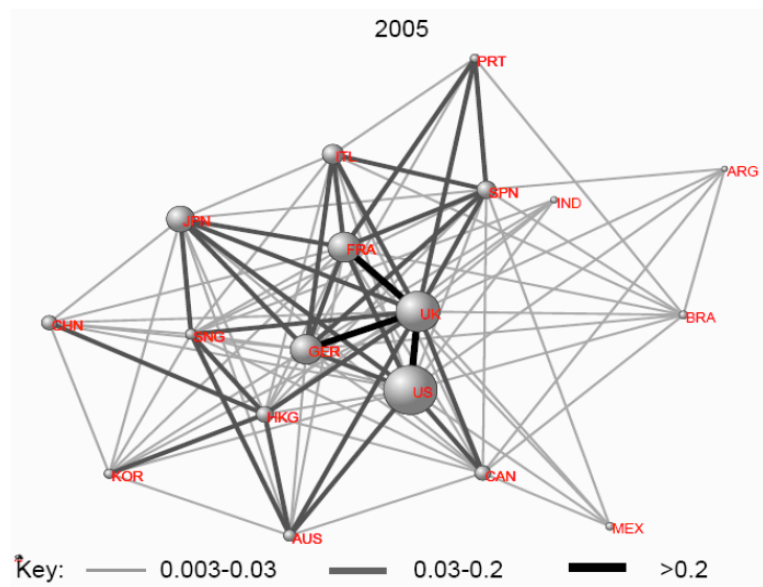
Chart 3: Global Financial Network: 2005

Figure 3 (source Haldane (2009)) The Global Financial Network in2005

In this case, the nodes correspond to countries and the size of the nodes to the total amount of foreign assets held by the country corresponding to the node in question. A link between countries means that at least one of the two holds the assets of the other. Typically one would define a minimum threshold for such assets to constitute the basis for a link. The thickness or weight of the link represents the sum of the mutually held assets. Once these definitions are established, one can calculate the empirical degree distribution and one can see what proportion of the total weight of all the links is made up by the total of the weights associated with the links emanating from the largest nodes. What we know is that, while the connectivity of the global financial network has increased remarkably in recent years (see Nier et al. 2007), the degree distribution[3] 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 realizing 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 it is clear that if networks are to be successfully incorporated into macroeconomic models two things are necessarty The first is to understand how networks, whether stochastic or deterministic, influence aggregate outcomes. The second is to understand how these networks form and if, and why, they persist.

Furthermore, understanding the evolution of 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).

Conclusion
Research on the origin of crises, bubbles, instabilities, and sudden phase changes in the state

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[3] The degree of a node is the number of links emanating from it.

of the economy has not been central to macroeconomics. Yet, the events of the last few years emphasise the importance of these phenomena. Practicioners, governments and central banks are very conscious that our knowledge of the economic mechanisms at work has to be improved, as the citations from Governors Trichet, King and Bernanke and those involved in managing investment funds show. Yet academic research on these subjects has not been high on the agenda.This is essentially because such research was incompatible with the premise of the rational representative agent, which had come to be thought of as being the only acceptable model.

This has led us to leave to one side the notion of financial fragility which implies that a given system might be more or less susceptible to producing crises. For instance, it seems clear that financial innovations prior to 2008 made the system more fragile. Apparently, the existing linkages within the worldwide, highly connected financial markets generated spillovers from the U.S. subprime problem to other layers of the financial system rather than diversifying and therefore diminishing risk. Many financial innovations had the effect of creating links between formerly unconnected players. All in all, the degree of connectivity of the system probably increased greatly over the last decades. As is well known from network theory in the natural sciences, a more highly connected system might be more efficient in coping with certain tasks but as in the case of electricity networks may also be more vulnerable to shocks and systemic failure. To understand when this is the case requires examining characteristics of financial networks other than just their connectivity.

There has been considerable analysis of network vulnerability in the computer-science and operations-research literature (e.g., Criado et al. 2005). Such research has, however, been largely absent from financial economics despite the efforts of the Bank of England for example. The introduction of new derivatives, it was argued, helped to improve liquidity and efficiency. But these claims were based on analogies with general-equilibrium models and and abstract theory of markets. More contingent claims, it was argued, help to achieve higher efficiency. Unfortunately, the claimed efficiency gains through derivatives are merely a theoretical implication of a highly stylized model and, therefore, should be seen as a *hypothesis* to be tested, not a fact that is assumed. In fact, there is hardly any supporting empirical evidence for, or analysis of, this question, and so the claimed real-world efficiency gain from derivatives is unjustified. But this reliance on existing but largely irrelevant theory had important consequences for the real world. Just as Barnett (2011) argues that individuals were induced to take what they thought were rational actions on the basis of poor information, so the idea that the system was made less risky by the development of more derivatives may have led financial actors to take positions with extreme degrees of leverage. The leverage of financial institutions rose, as I have mentioned earlier, to unprecedented levels prior to the crisis, partly by evading Basel capital regulations through structured investment vehicles (see Acharya and Schnabl (2009)). The interplay between leverage, connectivity, and systemic risk needs to be investigated at the aggregate level.

Furthermore, macroeconomists have to reconsider the role of information in financial and macroeconomic models. As we have seen the theory currently in use has systematically ignored a number of fundamental problems both with rational expectations and with the efficient markets hypothesis. As Poincaré already observed in 1900 the idea that information would be observed independently by market participants and that they would, by their actions, transmit that information into prices, took no account of the fact that individuals observe each other and infer information from the actions that they observe. To this must be added the consideration that the creation of new and complex instruments has a tendency to lose

information since it becomes costly to verify the quality of the underlying assets. Furthermore the empirical evidence does not lend support either to rational expectations nor to the efficient markets hypothesis. If we also consider the econometric problems associated with these assumptions it is clear that we need to rethink our models and to reconsider the informational role of prices and financial contracts. It is not enough, as some have done, to suggest that rating agencies do the job of verification. They also use models based on the basic theory and the standard loan-default models of the sort on which rating agencies relied, failed dramatically in recent years (Rajan et al. 2008). In addition it should also be noted as Hellwig (2008) has argued, that the price system itself can, like trading in securities markets, exacerbate problems rather than just neutrally transmitting information). One of the reasons for the sharp fall in the asset valuations of major banks was not only the loss in the assets on which their derivatives were based, but also the general reaction of the markets to this decline. As markets became aware of the risk involved, all all such assets were written down, and in this way a small sector of the market "contaminated" the rest. Large parts of the asset holdings of major banks quickly lost much of their value. Thus, the price system itself can be destabilizing as expectations change, and the consequences can be severe.

The regulatory system is clearly in need of an overhaul. However, if, as I believe, the system is constantly evolving it will not be possible to agree on a set of rules and then to make sure that they are implemented. This is, of course, what market participants want but since their behaviour,and the rules which they use, are constantly changing, the only possible way to control the system is to set up agencies which can monitor the system and look for early warnings of weaknesses and, in particular, signs of systemic failure. This is what the new European Systemic Risk Board is intended to do. From a theoretical point of view, we have no reason to believe that markets are self stabilising if left to themselves, they certainly self organise, often in unexpected ways, but this will not necessarily be a stable process.

Lastly, economists should try to develop models which incorporate the features that Governor Trichet mentioned. We have to use research in behavioural economics, to rethink our theories of expectations formation and to build more realistic models and , if these cannot be solved analytically to simulate them. In Kirman (2010) I outline two models which incorporate the sort of ideas that I am suggesting. One, Foellmer et al (2005), shows that as financial market participants follow forecasting rules which have proved successful in the past, herding will occur on certain rules. This will lead to a sequence of bubbles and crashes. The market will exhibit swings between bubbles, crashes and periods of relative stasis. There will be no convergence to a single price but in the limit the distribution of prices will converge. In such a situation, the timing of a switch will not be predictable but such a switch will be sure to occur. Furthermore, the probability of observing prices in any given range will be well defined. In the second model Anand et al. (2011) we analyse a situation in which there can be a sudden collapse of the prices of derivatives even though the rate of default on the underlying assets changes by a very small amount. There will be a sudden shift from a situation in which all market participants do not check the value of the underlying assets to one in which everyone does so. Individuals decide whether or not to check before buying an asset on the basis of the checking behaviour of their trading partners. What we are observing in such situations is what is referred to, in physics as a phase change. As someone said, « economists spent the twentieth century perfecting a model based on nineteenth century physics, perhaps we should, in the twenty first century, try to use some twentieth century physics.

At the very least we owe it to ourselves and to society to construct models based on sounder foundations which take into account some of the new research that Governor Trichet mentioned. As he euphemistically said, « Such approaches are worthy of our attention ».

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