THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

DINNER/DISCUSSION SUMMARY

Financial models – key tools for risk analysis or the vector of global financial collapse?

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Chair: **The Earl of Selborne KBE FRS**
Chairman, The Foundation for Science and Technology

Speakers: **Professor John Kay FBA**
Writer and Columnist, The Financial Times
Paul Sharma
Director, Wholesale Prudential Policy, Financial Services Authority
Professor David J. Hand FBA
President, Royal Statistical Society and Head of Statistics,
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PROFESSOR KAY explained the principles underlying the "value at risk" modelling that was in widespread use in the banking and financial sector, as mandated by the regulators. The approach by the mathematicians (the 'quant's') employed by the banks was to define the discrete asset classes of interest and to compute from historical data a variance/co-variance matrix that expressed the historical experience of returns on these asset classes and thus the value at risk, for example in terms of the maximum amount that might be expected to be lost on one day in a thousand and from such modelling calculate bank exposure in everyday times, and thus derive the required reserve asset ratios. These models were, however, only as good as their assumptions. In particular, the assumption was made of normality of the underlying distributions: experience of actual movements in price indices showed that extreme events occur much more often than the tail of the Gaussian distribution would indicate (the so-called 'fat tail' problem). And it was questionable whether in conditions of market stress the variance/co-variance matrix would be stable. The models could therefore show a bias towards significantly underestimating risk precisely in the conditions in which such errors would be most damaging. So the models worked, but could not be relied on when they were most needed.

Continuing, Professor Kay described the parallel problems that had arisen with the comparable models used by the credit rating agencies for evaluating risk on bundles of synthetic assets, such as packaged mortgage loans. The dangers were amplified by the ability of the banks to play the system by reverse engineering the characteristics of the modelling being used by the rating agencies and thus so package their assets such that they would be more likely to attract the highest rating. The effect was, on the one hand, to give the banking system greater credibility in its own eyes, and in the eyes of the regulator, for its use of quantitative modelling techniques whilst, on the other hand, leveraging the over-high ratings given by the agencies to its assets. All this came unstuck in July and August 2007 with the contagious collapse of confidence in the value of bank assets and thus in the solvency of the banks themselves.

Concluding, Professor Kay expressed scepticism about attempts to fix the problems of modelling economic and social systems with ever more sophisticated models. There would always be some in-model risk due to stochastic elements; but in addition there would always be off-model risk of events that no model-builder could reasonably anticipate. Instead, he advocated in economics and finance seeing the models as metaphors, some more powerful than others, but not as attempts directly to reflect reality. Their results were thus neither true nor false but could be used in context to illuminate the processes involved, and to suggest questions to be addressed thus assisting the good human judgment that in the end was what counted.

PAUL SHARMA explained the use to which banks and financial institutions put the results of their mathematical modelling. There was in his view no alternative to the widespread use of such techniques. Decisions had to be taken to buy or sell, banks had to decide on their reserve ratios, at some point debate had to end in a binary decision or a single number. Experience of unaided judgment was that it was inconsistent both between different decision-takers and over time, and could harbour unacknowledged biases. For the regulators it was hard to see what alternative there was to the use of mathematical models, and there was a real risk for the regulators that reliance on judgment alone could open up legal challenges to the competitive fairness and due process of regulation.

That said, Paul Sharma accepted that the recent use of mathematical modelling in the financial sector was problematic. He identified three main reasons:

- The problem of self-reference. The widespread use of credit risk models to affect credit decisions would itself affect the behaviour of those seeking credit. Not only the traders would use a model but so would all the other players. The act of modelling thus changed what was being modelled, a difference from the use of mathematical modelling of most physical systems.

- The problem of extreme events. Other domains had similar issues of low probability but high impact events, for example the need to predict the incidence of severe flooding or hurricanes. In some physical situations it was possible to see an extreme event as a larger scale version of a normal event. A system breakdown might arise from the rare simultaneous compounding occurrence of a number of 'normal' failures. More typically, however, the extreme event (such as a Tsunami) had entirely different causes from the normal event (such as normal wave formation). The risks of such events could not therefore be deduced from modelling of past normal events. By their nature however data for modelling extreme events of that kind is sparse.

- The problem of data collection. Lack of relevant data was the limiting factor for many attempts to model financial systems. Those involved were likely to be more attracted to the technical challenges of extending the models themselves, adding to their complexity and mathematical sophistication, rather than the less glamorous statistical task of data acquisition. Data issues had therefore received insufficient resource, and statistical techniques such as the use of proxy data had been relatively neglected.

PROFESSOR HAND warned against the natural tendency to try to reduce to single causes the explanation of failures in complex systems such as had occurred recently in the financial sector. In assessing what part of the problems that had arisen were actually due to mathematical modelling we should see the use of the results of these models in the context of the complex human and institutional behaviours involved. We should ask therefore not just whether the models were sound in their own terms but whether there was over-reliance on their results and whether warnings were sounded about their use, and if sounded whether they were heeded, and if not, why not.

Working through this analysis, Professor Hand suggested that it would be reasonable to assume, given the abilities of those concerned, that the mathematics of the various models would have been sound, and as deductive logic the conclusions would in that sense also have been sound. Were, however, the assumptions of the models appropriate given the likely use of the results? Whose task would it have been to check that? He suggested that there was an unstated core belief amongst the user institutions that a form of natural selection would favour useful innovations and winnow out the less valid, so continued use of a model by an apparently successful financial organisation was itself evidence of its fitness for purpose. This was to misunderstand

the nature of evolution as a 'blind' force. The assumption of Gaussian distributions for market price movements where assets could be sold rapidly and easily was known not to reflect reality. Unlike most physical systems where the law of large numbers allowed data reflecting inherent randomness to be reduced to statistical regularity, human behaviours and choices tended to have individual motivations, and beneath apparent large scale regularity would lie further layers of complexity (a point he illustrated with his research on the distribution of amounts individual drivers spent in buying petrol at filling stations, biased towards 'round' numbers of pence as well as pounds). The likely problems with individual credit risk models, with such assumptions, were compounded when there results were combined, producing a picture which certainly would not reflect the complexity of interactions in the overall system.

Developing this argument, Professor Hand suggested that the main focus for explaining what had happened should be on examining the quality of communication and understanding between modellers and users, and the extent to which the latter were operating a system that they did not understand on the basis of results whose limitations they did not properly realise. So questions should be asked about why talented people allowed themselves to be put in such a situation, and about those who appointed them. Nor was it sufficient, if the case, to point to some warnings having been given. The reasons for everyone continuing to operate on this flawed basis surely lay in the fact that, up to the crash, the system generated substantial profit. Better warnings might have helped, but possibly not given the hedge fund bonus structures, rating agency rewards and other perverse incentives for all concerned to keep going with the strategy, to which should be added staff mobility and the moral hazard due to the expectation of bail-out. In conclusion, Professor Hand advised against simply blaming the mathematicians, and instead seeing the explanation as lying in the context in which they were operating. We had to accept that the modern world is built on mathematics.

In discussion of the assumptions behind the mathematical models, it was pointed out that there could be additional problems with the use of continuous variables to represent discrete price movements, given gaps between trades in individual assets, although this was probably not as big a source of error as the 'brownian motion' approach to price movement distributions. There was agreement on the importance of data availability for extreme events, an example being the modelling of risk premiums based mortgage history that only went back to the 1990s, a period of growth not decline in prices. Another issue arose over the fundamental assumption that trades made on the basis of the model did not themselves alter the operation of the model. It was however not safe to assume that trades were marginal in relation to the overall stock of assets. It was pointed out that many of these issues were more in the domain of the statistician than the mathematician. It was however argued that ambitions to add further refinement and complexity to mathematical models of financial systems was misguided since they could never reflect reality. It would be better to stick to simple models using the most significant variables, test ranges of assumptions and approaches, and then apply judgment to the resulting spread of results.

It was suggested that encouragement from the Basel regulators (Bank for International Settlements) had led to the widespread use of these quantitative techniques. On the other hand, it was the case that decisions had had to be made on the level of bank capital. Either this might have been done by a central formula, the basis of which would not have been at all straightforward to assess given the complexity of a modern bank's asset base, or as had happened the regulators allowed individual institutions, under supervision, to employ modelling. Neither approach was ideal. It would have been better for the institutions to employ a range of independent models to look at the spread of results as was the practice in most government departments such as DEFRA.

In further discussion, it was suggested that the academic financial mathematics community had consistently and over a long period warned of the problems being discussed, in particular the assumption of normality. It was confirmed that indeed the FSA had been well aware of the academic debates over the appropriateness of the models being used, and had at times raised these issues in regulatory discussion with the sector. But what were these institutions to do with this knowledge that the modelling was probably problematical? The hard fact was that despite such theoretical arguments there had been a powerful business judgment overlay: the approach being taken at that time was generating very substantial profit and there was no incentive to change it. It might have been the case that due to the nature of its business the insurance industry had taken a longer term approach, with those engaged in daily trading a short-term one and the banks overall somewhere in the middle. The short term incentivised bonus culture had not helped, but that was not a sole cause and the comment was made that had the individuals and institutions concerned actually appreciated what their approach would lead to they would not, in their own interests, gone on acting as they did.

The issue of communication between modellers and users was discussed and unfavourable comparison drawn with the professional standards of other groups such as engineers working with clients. In the case of the 'quant's' it was, not entirely in jest, suggested that as typical introverted mathematicians their ability to initiate and sustain effective communication with the business level was likely to have left the latter under-appreciative of the inherent limitations of their work.

In concluding discussion, once again the difference was emphasised between modelling the natural world and that of human behaviour in the social and economic sciences. The question remained, if not modelling, then what? And the most appropriate answer was likely to be a combination of better understanding of complex system behaviour and behaviourally based models, simplification and abstraction to the essentials, and adding an essential element of practical experience and judgement. Which took discussion back to a quotation from Keynes that Professor Kay had shown at the outset of the evening:

"Professor [Max] Planck, of Berlin, the famous originator of the Quantum Theory, once remarked to me that in early life he had thought of studying economics, but had found it too difficult! Professor Planck could easily master the whole corpus of mathematical economics in a few days. He did not mean that! But the amalgam of logic and intuition and the wide knowledge of facts, most of which are not precise, which is required for economic interpretation in its highest form is, quite truly, overwhelmingly difficult for those whose gift mainly consists in the power to imagine and pursue to their furthest points the implications and prior conditions of comparatively simple facts which are known with a high degree of precision." John Maynard Keynes, 'Alfred Marshall: 1842-1924' (1924), cited in Geoffrey Keynes (ed.), *Essays in Biography* (1933)

Sir David Omand GCB

Web Links:

Bank for International Settlements
www.bis.org

Department of Mathematics, Imperial College, London
www3.imperial.ac.uk/mathematics

Engineering and Physical Sciences Research Council
www.epsrc.ac.uk

Financial Services Authority
www.fsa.gov.uk

The Financial Times
www.ft.com

The Foundation for Science and Technology
www.foundation.org.uk

HM Treasury
www.hm-treasury.gov.uk

John Kay
www.johnkay.com

Research Councils UK
www.rcuk.ac.uk

The Turner Review
www.fsa.gov.uk/pages/Library/Corporate/turner/index.shtml

The Royal Statistical Society
www.rss.org.uk