

Report on the ESRC–Oxford Martin School International Macro Symposium, Oxford University, October 1-2, 2012

Executive summary

The Symposium was inspired by the critical light the global financial crisis and its aftermath threw on the capabilities and limitations of established thinking in macroeconomics. Around 60 researchers attended, many of high international repute, reflecting a wide spectrum of approaches to macroeconomic research and teaching. The presenters and discussants, all leading figures in their field, generated lively and mostly good-natured open-floor discussions casting invaluable light on present issues and debates. The symposium clarified that many crucial macroeconomic problems remain and that support for theoretical, empirical and policy related research is essential. It also revealed a diversity of approaches with promise to challenge the current monolithic view.

One important developing area is the incorporation of a banking sector, leverage and defaults into dynamic stochastic general equilibrium (DSGE) models and in stylised text-book teaching of macroeconomics. A second area concerns models with limitations on the information processing capacity of agents which also introduce useful new insights into general equilibrium and the study of economic dynamics. Thirdly, agent-based modelling with data-intensive micro-structure and heuristics of varying levels of sophistication for household, firms and bank decisions promises valuable new understandings. So do systems analyses of feedbacks, interconnectedness and contagion, particularly in finance, drawing analogies from ecology and epidemiology. The efficient market paradigm came in for serious criticism from researchers studying market microstructure.

It was widely felt that macroeconomics had spent decades under artificial blindfolds that prevented the kind of learning from data prevalent in the natural sciences. New econometric tools were discussed with high promise for inference, robust forecasting and policy: models were presented for empirically investigating interactions between the financial sector and the real economy under conditions of structural change. On the data side, constructive suggestions on survey data were made and public investment in UK data was unfavourably compared with that in the US.

It is clear that the ESRC needs to develop a new cohort of researchers via PhD, post-doctoral research fellowships (PDRFs) and new blood appointments as well as research projects, not necessarily all of a large scale. A competitive bidding process is essential to select which researchers and approaches to support, using a diversity of international referees covering a wider range of different interests than prevalent in recent years. A concern remains that a small coterie of specialised economists on the grant assessment panels cannot encompass the diversity of approaches now required.

Background

The International Scientific Symposium on Macroeconomics was held on October 1-2 at the James Martin School in Oxford, an appropriate location given the focus of this interdisciplinary school of leading thinkers on problems mankind faces in the 21st Century. The idea for the symposium took its cue from the events of 2007–9. These global events have stimulated macroeconomic thinking into previously unexplored or under-explored avenues, and have cast a critical light on the capabilities and limitations of established thinking around DSGE models and their variants. Some have argued for different approaches not based upon micro-foundations—or at least not on conventional hyper-rational micro-foundations. The ESRC (in discussion with similar leading international bodies) believes action is required to catalyse new approaches to macroeconomic questions and help develop the discipline's responses, perhaps in partnership with other disciplines within or beyond social science. The symposium provided an opportunity to bring together a range of perspectives on identifying future directions for macroeconomic research. There is the prospect of a \$10m investment from the ESRC and its partners to follow up the best ideas from the symposium. The output from the symposium will form an input into the Council's research development plans for 2012 onwards, and especially the next competition for Centres/Large Grants.

The 2007–9 financial crisis was precipitated by a unique combination of events to which many commentators have suggested the response of mainstream macroeconomic thinking was inadequate. The future focus of world-leading macroeconomic research could encompass one or more of the following:

- deepen the range of analytical and mathematical frameworks within the DSGE approach, incorporating further financial market frictions into models and the roles of policy and regulation in financial markets;
- address a range of issues not previously considered mainstream to the discipline, including agent-based models, other complexity science based approaches, and non-equilibrium modelling;
- import systems-based approaches from modern physics or biology, including network analysis;
- engage more with further dimensions of micro-economics e.g. behavioural approaches and recent insights as to their biological underpinning;
- place much greater emphasis on the role of evidence.

The International Benchmarking Review of UK Economics (ESRC, RES 2008) identified UK capacity in macroeconomics as an area of particular concern, noting that “UK researchers are not very visible in major areas of macroeconomics—such as international macro, business cycles, macro-econometrics and ‘new’ Keynesian economics.”

The ESRC aims to act now to develop the international leadership capability of UK macroeconomic research, and identify where intervention is required to catalyse thinking and to build capacity.

On the structure of the keynote addresses

Keynote speakers were invited to cover issues from a range of perspectives. To assist a comparative assessment, the keynote speakers and discussants were asked how their particular approach to macroeconomics addressed at least some of the following phenomena:

- The secular rise in the ratio of private sector debt to GDP in many economies such as the US and UK.
- The secular rise in the profit share in national income.
- The secular rise in earnings inequality.
- The secular fall in the household savings ratio.
- The shifting correlations between credit growth and economic growth.
- Asset pricing puzzles such as the excess volatility, predictability and size of the equity premium.
- The causes and dynamics of the global financial crisis.
- What policies might be appropriate in the aftermath of the global financial crisis.

This is not to say that all approaches should necessarily have a complete story for each of these phenomena. Different approaches may offer far more powerful insights into some of these questions than others.

On the structure of symposium

The symposium was divided into ten one-hour sessions with a 30 minute presentation, followed by 15 minutes of formal discussion from a leading expert, and 15 minutes of open-floor debate. Coffee breaks, lunches, and a dinner at Nuffield College provided opportunities for intensive further interchanges. Participants found the event highly stimulating and productive, because of the challenging diversity of lines of enquiry and the quality of the presenters and discussants, and of the open debate. The symposium therefore achieved its aims and promises to be an important potential resource for students and researchers in economics. Details of the programme are shown below.

ESRC–Oxford Martin School International Macro Symposium, Oxford University

Programme

Monday 1 October 2012

Oxford Martin School, Old Indian Institute, 34 Broad Street, Oxford, OX1 3BD

Time	Event	Details
11:00-12:00	Registration and coffee	
12:00-12:30	Welcome remarks	Adrian Alsop (ESRC) and David Hendry (Oxford)
12:30-14:00	Lunch	Balliol College
14:00-16:00	Session 1	
	Chair	Seppo Honkapohja (Bank of Finland)
14:00-15:00		DSGE Models and the Financial Crisis
	Speaker	Mark Gertler (NYU)
	Discussant	Simon Wren-Lewis (Oxford)
15:00-16:00		Macroeconomic Models where Agents Choose to Learn: Attention, Disagreement, and Policy Communication
	Speaker	Ricardo Reis (Columbia)
	Discussant	Bartosz Mackowiak (ECB)
16:00-16:30	Coffee break	
16:30-18:30	Session 2	
	Chair	Katarina Juselius (University of Copenhagen)
16:30-17:30		Sovereign Debt, Government Myopia and the Financial Sector
	Speaker	Viral Acharya (Stern)
	Discussant	Martin Ellison (Oxford)
17:30-18:30		The Contribution of Agent-based Modelling
	Speaker	Scott Page (U. of Michigan)
	Discussant	Domenico Delli Gatti (Catholic University, Milan)
19:00 for 19:15	Conference dinner	Nuffield College
	Speaker	Paul Tucker (Bank of England)

Tuesday 2 October 2012

Oxford Martin School, Old Indian Institute, 34 Broad Street, Oxford, OX1 3BD

Time	Event	Details
8:30-9:00	Coffee	
9:00-11:00	Session 3	
	Chair	Philippe Moutot (ECB)
9:00-10:00		Modelling Interactions of Finance and the Real Economy
	Speaker	John Muellbauer (Oxford)
	Discussant	Katarina Juselius (Copenhagen)
10:00-11:00		The endogenous dynamics of markets: price impact, feedback loops and instabilities
	Speaker	Jean-Philippe Bouchaud (Paris)
	Discussant	Doyne Farmer (Santa Fe Institute and Oxford)
11:00-11:15	Coffee break	
11:15-13:15	Session 4	
	Chair	Richard Portes (CEPR & London Business School)
11:15-12:15		Financial Networks and Contagion: Learning from Ecology and Epidemiology
	Speaker	Sujit Kapadia (Bank of England)
	Discussant	Neil Ferguson (Mathematical Biology, Imperial College)
12:15-13:15		Deciding between Alternative Approaches
	Speaker	David Hendry (Oxford)
	Discussant	Kevin Hoover (Duke)
13:15-14:30	Lunch	Balliol College
14:30-16:30	Session 5	
	Chair	Charles Goodhart (LSE & Financial Markets Group)
14:30-15:30		What Macro Do Students Need?
	Speaker	John Beath (Royal Economic Society and St Andrews)
	Discussant	Wendy Carlin (UCL)
15:30-16:30		Roundtable : What New Data Does Macro Need?
	Panellists	Bernhard Winkler (ECB), Liz Dixon Smith (Financial Stability Division, Bank of England), Martin Weale (MPC), Neil Ericsson (Federal Reserve Board), John Muellbauer (Oxford) and Joe Grice (ONS)
16:30	Conference wrap-up and closing remarks	David Hendry (Oxford)
16:45	Coffee and conclusion of symposium	

A summary of the symposium

The day began with an introduction by the ESRC's Adrian Alsop, outlining the background as summarised above, and noting the Queen's famous question: why did economists not foresee the crisis? He noted that although macroeconomists represented only a subset of the profession, a cloud had been cast over all of economics, and perhaps even social science more broadly.

Mark Gertler (New York)

agreed that 2007-vintage DSGE models had failed—they were better at explaining the 1970s than the 2000s. He addressed the question of whether a DSGE model could incorporate a banking sector with financial frictions in order to throw light on quantitative easing as a central bank policy response to a financial crisis. In his model (joint work with Peter Karadi), private banks may divert a proportion θ of loaned funds by paying excessive dividends or bonuses, and depositors can only claim the residual value of banks, which includes its equity. Banks can also divert part of their holding of bonds, but to a lesser extent. A financial crisis might then be thought of, as suggested by the discussant, **Simon Wren-Lewis (Oxford)**, as a particularly bad episode of large θ . Banks are subject to a leverage constraint which limits the loans they can make and the bonds they can own relative to their net worth. While the central bank is less efficient at intermediating securities than the private banks, it is not balance-sheet constrained and can therefore buy government bonds, driving down long-term interest rates, when private banks have seriously impaired balance sheets. This is an example of Quantitative Easing (QE) and the model could also discuss the QE choice between purchases of private securities vs. government bonds. The model also has conventional monetary policy, which may be subject to a zero lower bound. Though highly stylised, and embedded in a stripped down New Keynesian model with nominal inertia and other frictions, to give a simple general equilibrium closure, it was felt to be a useful advance, particularly as a framework for teaching the introduction of banking into general equilibrium macro. The simulations of the calibrated model were able to achieve QE effects broadly in line with recent empirical estimates, but, as the discussant pointed out, unrealistically low persistence in dynamics. The omission of housing and mortgage markets, with no house price and foreclosure dynamics, and feedbacks onto the availability, as well as the price, of credit were felt to be serious limitations of this kind of stylised parable. A question was raised about the international dimensions of the crisis, absent from this closed economy model.

Ricardo Reis (Columbia)

put into perspective the resurgence of research into imperfect information, including work on strategic interactions, how agents take into account the forecasts of others, rational inattention, choosing to learn, and empirical applications of these ideas. He argued that many macroeconomic issues were illuminated by this literature, including the Phillips curve and inflation dynamics; the equity premium and home-bias puzzles in finance, and financial contagion; why many consumers appear to live hand-to-mouth; and why different agents may initially disagree about the interpretation of new data and policy announcements. He

proposed a general formulation of information choice where agents jointly choose actions and information, subject to a cost of obtaining and processing this information. If there is fixed cost of observing something, one obtains inattentiveness, under which agents update their information sets only once in a while, but do so more frequently in environments where the potential gains are greater. Survey data on expectations can illuminate how dispersed are beliefs, how fast people learn, whether they learn from each other and learn about different pieces of information at different speeds. He argued that information theory typically implies randomized, discrete, infrequent adjustment, suggesting the multinomial logit model of discrete choice could have powerful empirical applications, for example to model individual heterogeneity and aggregate dynamics of price adjustment. Such dynamics would have elements of staggering as well as synchronized behaviour.

He applied these ideas to various aspects of the global financial crisis, including to the biases of rating agencies and how financial crises can arise. Initial differences in information are magnified by portfolio choice (e.g. subject to home bias) and allocation of attention, resulting in excessive risk-taking. Corner solutions at the individual level can translate into rapid aggregate responses, potentially leading to price frenzies under some circumstances and even closure of certain markets. Bad news on one asset, partly attributed to others, can lead to price contagion. During the Great Moderation, however, consumers were generally fairly inattentive since fluctuations in data were small, contributing to low volatility of consumption, despite the build-up of underlying global imbalances. When large shocks arrived, consumers became far more attentive and reacted accordingly.

The discussant, **Bartosz Mackowiak (European Central Bank)** highlighted the contribution of these ideas to solving a puzzle for many DSGE models, namely explaining persistence in macro data. In standard DSGE models a number of different sources of persistence such as habits and adjustment costs need to be introduced to capture inertia. As Sims (1998) originally conjectured, rational inattention could be a single source of inertia. His own work had shown that rational inattention as a source of persistence has rather different policy implications than DSGE models with multiple frictions to account for similar levels of persistence. The discussion raised issues regarding Ricardo Reis's example of traders with over-optimistic expectations of house prices: did they simply have the wrong distributions? Reis noted that the distinction between risk and uncertainty was missing in this literature. And it was argued that housing market participants had not understood the consequences of financial innovation and the possibility of high levels of foreclosures.

Professor Reis expressed his preference for using 'model-consistent' rather than 'rational expectations' terminology. Among other issues discussed, it was noted that the rational inattention framework implied that more information or better information processing capacity did not always lead to better outcomes.

Viral Acharya (Stern School, New York)

took part via a video-link from New York to address another aspect of the aftermath of financial crises, namely potential sovereign debt default. The intuition behind this paper (with Raghuraj Rajan) is that countries such as Greece or Italy, where a high proportion of

sovereign debt is held by the banking system, would find the disruption of credit flows and intermediation to the domestic economy caused by a default very costly. As the discussant, **Martin Ellison (Oxford)**, explained, this reason for not defaulting is quite different from the traditional one in which governments trade off the short-term relief from defaulting against the long-term cost of being shut out of international capital markets so that more myopic governments who discount the future heavily are more likely to default. In the Acharya story, the very myopia of governments can be a factor *reducing* the incidence of defaults. And the entanglement of government debt with the financial system can increase market confidence that sovereign debt default is unlikely, so keeping down the funding costs. Though governments are myopic, there are still long-term trade-offs in the set-up Acharya analyses. These arise since new myopic governments replace previous ones and the tax and spend decisions of each government impact on the accumulation of private capital and the taxable capacity of the private sector relevant for servicing future debt. The presentation generated much discussion, since the premises on which the model was constructed differ so radically from more standard approaches with rational decision makers taking the long view. Moreover, some of the general empirical implications seem at odds with the debt history of economies such as the UK.

Scott Page (University of Michigan)

gave a broad overview of agent-based models (ABM) for macroeconomics with a number of examples of existing work. These are models of complex adaptive systems in which a multitude of (heterogeneous) agents interact with each other and the environment, and in which aggregate variables such as GDP are computed from the bottom up. As the discussant **Domenico delli Gatti (Catholic University, Milan)**, himself an experienced practitioner, explained, for a population of heterogeneous agents such as households or banks, the main steps are: write behavioural rules for each agent; translate rules into code; calibrate the parameters, run simulations, analyse the properties of the simulated data, and compare with “stylised facts” from real world data. This has considerable similarity with DSGE modelling, but as Scott Page argued, quoting Solow: “DSGE + heterogeneous agents + adaptation + network effects = complex system”. The dynamics of such systems can be non-linear, giving rise to large events and long-tailed distributions, and far from steady-state behavior. Scott Page argued that such systems were less likely to exhibit stable equilibrium correcting behavior than robustness—the ability to maintain functionality to external trauma and internal dynamics. The diversity of the parts and complexity of the process can contribute to robustness, but as Sujit Kapadia pointed out later, is far from guaranteed. Scott Page gave examples of agent-based modeling by LeBaron on the stock market which addressed long-standing pricing puzzles; work on the Washington DC housing market by Doyne Farmer and others, addressing issues such as the effect of credit relaxation on house prices and foreclosure dynamics to illuminate systemic risk issues; Axtell’s labour market model aiming to replicate stylized facts on firm size statics and dynamics, firm creation and destruction, growth, age, output, turnover, and productivity as well as worker income, job tenure, job-to-job flows, hiring, and unemployment; and mentioned the Eurace Unibi model, an ongoing project incorporating households, firms and banks. In the discussion, the use of heuristics describing behaviour rather than extreme assumptions about the information-processing and

decision-making capacity of individuals was seen as a distinctive advantage of the ABM approach. Contrasts and parallels with heterogeneous optimizing models were made. And the 'big data' needs and opportunities of agent based modeling were seen as a virtue. However, the focus on "stylized facts" was seen as problematic: which "facts" are seen as relevant, and which are to be ignored? A better way forward is likely to be the fitting of more comprehensive time-series econometric models to describe the aggregate variables of interest generated by simulations from agent-based models and comparing these with the similar econometric models fitted to actual data.

The general discussion raised a question about the example of loops in the Beveridge curve used in Page's presentation: any 3-dimensional model projected in 2 dimensions could show loops. Was an agent-based model just standard macro with heterogeneity? Systemic properties, emerging outcomes and inequality made the agent-based approach generally different. It was agreed that the distributional implications in cross-sections and long-tailed time-series of agent-based models needed better econometric evaluation criteria than just matching a few stylized facts or the running of simple computer-based horse-races.

Paul Tucker (Deputy Governor, Bank of England)

At the conference dinner, Paul Tucker observed that, alongside bankers themselves, economists had got much of the blame for the crisis. The accusation was that mainstream models had made simplifying assumptions that had come badly unstuck. Mr Tucker doubted that many leading economists had seriously 'moved into' their modelled world. But in any case even if they had, they were not responsible for policy. By contrast, policymakers have a special responsibility to 'suspend belief' when employing models. All that should matter to them is grasping the way the world works, and helping it to work better. If economics cannot explain, with a structural model, something that is widely perceived to occur, policymakers should not ignore the phenomenon. Bubbles, the search for yield and, more or less, anything whose effects violate Modigliani-Miller arguably fell into this category in the past. There were two underlying problems. One was a lack of charity, within economics, in listening to views across disciplinary boundaries or schools of thought. Finance and macro, in particular, were too far apart. The other, deeper problem, he argued, was epistemological. 'It is no good policymakers counting as 'knowledge' only those things that are accepted as robust features of the data or as 'results' from a structural model.'

Some things can be 'known' by, for example, financial market practitioners in the same way that GE Moore knew he existed when, famously, he waved his hand at his philosophy class in Cambridge approaching a century ago. That kind of 'informal' knowledge should prompt our curiosity and engagement as economists and policymakers.

Another possible example is the so-called 'risk channel' of monetary policy. Until recently, policymakers have had a tendency to doubt suggestions that persistently accommodative policy fuelled risk taking. But there is emerging evidence that monetary policy can affect term premia. Both Jeremy Stein and Paul Tucker himself had set that out publicly. He mentioned this not because monetary policymakers should necessarily avoid policies that

affect risk taking, but rather because the other, financial-stability side of our brains – in the UK, the Bank’s Financial Policy Committee – should be alive to those effects when setting regulatory policy for banking. Making a success of that, he argued, calls for curiosity and generosity of spirit in our enquiries and work. If nothing else, this conference would surely have helped to foster that spirit.

John Muellbauer (INET@Oxford Martin School)

focused on empirically modeling interactions of finance and the real economy (in joint work with John Duca and Anthony Murphy), with special attention on the household financial accelerator. After the global financial crisis, data from the financial flow of funds, previously relatively neglected, are now seen as crucial to the data monitoring carried out by central banks. His talk revisited earlier efforts to understand financial-real linkages, such those of Tobin and the Yale School, and proposed a modeling framework for analysing the household flow of funds jointly with consumption. The consumption function incorporates household income, portfolios of assets and debt held at the end of the previous period, credit availability, and asset prices and interest rates. In a general equilibrium setting, these all have to be endogenised, and since households make consumption and housing purchase decisions jointly with portfolio decisions, there is much to be gained in modeling a household sub-system of equations. Major evolutionary structural change – namely the evolving credit architecture facing households – is handled in a ‘Latent Interactive Variable Equation System’. A latent variable measuring the state of credit availability enters each equation as an intercept effect but also interacting with key variables to capture, for example, the shifting marginal propensity to spend out of housing wealth. A by-product is improved understanding of the secular decline in US saving rate, as well as of the household financial accelerator. This accelerator works through three main feedback channels: negative shocks reduce house prices and residential construction, a volatile part of aggregate demand. Lower house prices directly reduce household spending through the housing collateral channel. Sharply lower house prices raise foreclosures and mortgage delinquencies, damaging the asset base of banks and their ability to extend credit and raising risk spreads in other credit markets. There is pronounced amplification of shocks in serious downturns. The credit crunch further reduces spending, asset prices and economic activity. Moreover, the models discussed offer new ways of interpreting data on credit, money and asset prices, which are crucial for central banks. The models also highlight major differences between economies in the operation of these feedback mechanisms: the US, for example, is quite different from Germany and Japan in this respect.

A very late cancellation by the scheduled discussant, Lucrezia Reichlin, led to a quickly improvised discussion in two parts. First, John Muellbauer raised two points from previous presentations: could the estimated latent variable, here interpreted as the time-varying marginal propensity to consume out of housing collateral, not reflect other influences? Wasn’t the consumption model just a non-structural ‘kitchen-sink’ regression? It would be hard to think of other influences with the same volatile time profile and similar impact on consumption, the mortgage refinance rate, the mortgage stock etc. Evidence from other

countries and parameter stability of the model suggests the consumption equation is ‘structural’ in the Cowles-Commission sense. **Katarina Juselius (Copenhagen)** led a second part of the discussion, putting into perspective the difficulties of understanding long-run fluctuations of asset prices and the exchange rate in models without structural breaks or evolutionary change.

The wider discussion bore on micro-evidence with similar implications, and on the policy relevance, most recently with Ben Bernanke’s presentation of QE3 focused on mortgage-backed security purchases to lower long term interest rates and improve credit flows.

Jean-Philippe Bouchaud (Paris)

criticised the efficient markets view that asset prices reflect fundamental values, move only in response to exogenous unpredictable news, and are fundamentally stable because differences are arbitrated away by those who know. Instead he argued that humans are swamped by superabundant but noisy information and *radical uncertainty*. We make mistakes and are subject to biases, relying on heuristic rules to make suboptimal decisions. Further, we are strongly influenced by the behaviour of others (who might have more information) – so that panic can feed panic. We are strongly influenced by past patterns (that might repeat) – so trends feed trends as in extrapolative expectations. However, theories that treat these effects consistently are still at an early stage. He observed that all trades, even small ones, and whether informed or not, impact on prices. Empirical work had suggested that only around 5% of asset price changes of four standard deviations or more were due to news, and perhaps only 20% of all asset prices changes. Since there is no easy way to distinguish “informed” from “uninformed” traders, all trades statistically impact prices. Agents believe or fear that trades might contain useful information they don’t have, creating a potential transmission belt for feedback loops and avalanches. He described some of the other stylised facts about asset price dynamics, whatever the market – equities, bonds, forex: the power law of jump sizes and excess volatility with long-range memory closely resembles endogenous intermittent noise in complex systems e.g. of turbulence in fluid dynamics.

The study of the price impact of trades demonstrates that as the price moves away from the last market price, the number of offers increases nonlinearly, creating disproportionately greater liquidity and opposing further deviations of the price, but with very little liquidity at the mid-price. Since the price impact depends on the size of a trade relative to market volume, there is a non-linear relationship between trade-size/volume and price impact. The evidence cited by Bouchaud favours the square root law as a close approximation over all types of high frequency asset markets. This argues for liquidity fluctuations playing a crucial role in explaining micro-crises and jumps in prices without news, and that regulation should engineer stabilising feedback loops favouring liquidity when it is most needed. Furthermore, strong distortion or amplification mechanisms can arise through fads, fashions and other social interactions. With a simple model of heterogeneous behaviour influenced by public information and the behaviour of others, he demonstrated how aggregate behaviour can respond non-linearly to public information, creating sharp discontinuities at the macro level depending on the degrees of heterogeneity and of social imitation.

The discussant, **Doyne Farmer (Santa Fe Institute and Department of Mathematics Oxford)**, explained that the square root law of market impact arose from a combination of ‘no-arbitrage’ (i.e. that no further arbitrage opportunities remained to be exploited) and diffusion. It arises naturally from locally perturbing excess demand and the universal functional form was a remarkable empirical fact. It clarified that market dynamics involved transactions causing price movements, as well as price movements causing transactions. It had clear implications for market execution tactics, suggested limits on fund sizes and was helpful in developing understandings of market ecology – how strategies interact, which will grow and which fade. Market efficiency requires arbitrageurs, but arbitrageurs require inefficient markets. Inefficiencies are driven by demand for liquidity and diversification. And these inefficiencies support a rich ecology of predators. The theory of market impact makes it possible to study the market ‘food web’ and examine mechanisms such as predator-prey, competition and symbiosis. However, empirical study needed hard to come by data with counter-party identifiers. He hypothesised that market crises are driven by disruptions of ecology. One of the practical applications of these empirically-founded theories was to the problem of how to estimate the liquidation value of a position, where liquidation takes place in a sequence of trades. This would generally be significantly below the current market value and this is relevant in computing the leverage of a position. Regarding financial instability, he argued that most network models so far treat cascading failures due to counterparty risk. But according to the New York Fed much of the 2007–9 crisis was transmitted through common asset portfolios. This means that contagion must be understood through models that combine market impact and network effects. He agreed with Bouchaud that clustered volatility and extreme risks are largely endogenous and, at least on short time scales, are driven by liquidity fluctuations, i.e. fluctuations in market impact.

In the general discussion, the micro-structure approach of Bouchaud and Farmer, was admired, but it was argued that non-efficient market approaches in macro-finance were actually quite common, for example with feedback loops analysed by Brunnermeier and Pedersen or Scheinkman’s work on noise-traders and bubbles. Empirical work on asset prices had often used ‘event studies’ and found that the impact of ‘news’ was very context dependent. The presence of heterogeneous cash-constrained agents in general equilibrium was proposed as a major difference from standard macro and linked with Bouchaud’s focus on liquidity.

Sujit Kapadia (Bank of England)

discussed what can be learned from ecological and epidemiological examples and techniques about the causes and dynamics of the global financial crisis and appropriate policy responses in the aftermath of the crisis. He illustrated the interconnectedness and concentration of the financial system, the increase in its leverage, and in its homogeneity. Many economists and industry folk saw this as a by-product of technical progress, and as welcome steps towards the completion of markets, with better risk management, so good for stability. An ecologist, however, would have seen dangers, since complexity and homogeneity together increase

fragility, whereas simple or modular systems are more robust. Pre-crisis financial regulation tended to be static and focused on individual institutional risk without considering risk of systemic failure. Ecologists see system-wide management as necessary while epidemiology looks for tipping points and super-spreaders in considering how infectious diseases spread. Highly connected ‘super-spreaders’ are key to the propagation of contagion with a natural policy response to target those super-spreaders, e.g., by vaccination. Given complex networks in finance, key dimensions of systemic risk arise through contagion, non-linearities, the special role of key players, and system dynamics with behavioural feedbacks and amplifiers. Financial systems have some special features compared to typical systems in epidemiology, such as complex network structures with directed and weighted links, local dependence and balance sheets with liquidity and solvency constraints, which generate additional complexity and non-linearity. Behavioural responses can result in default contagion and asset fire sales.

Sujit Kapadia also discussed the macro-prudential implications that stem from this approach. These include capital and liquidity surcharges for systemically important financial institutions (SIFIs) and risk weights on intra-financial system exposures with the aim to make key nodes more resilient and incentivise banks to become less systemically important. Time-varying policies to mitigate effects of the cycle, better data and greater transparency, netting and central clearing of derivatives, increased simplicity, for example in the range of derivative contracts, and greater modularity are all supported by this kind of complex network analysis drawing on ecology and epidemiology. Important examples of greater modularity are the Vickers Commission proposal about ring-fencing retail and investment components of large banks, the Volcker rule, and living wills. He concluded with challenges for future work including developing stronger roles for behavioural considerations, uncertainty, endogenous shocks and empirical evidence. Integration with agent-based models is likely to prove important. Finally, the paradox in ecology over whether modularity with diversity or modularity with simplicity is better for stability needed further analysis in financial systems.

Neil Ferguson (Imperial College), the discussant, began with a fascinating historic overview of how thinking in ecology had changed. Forty or more years ago, ‘fitness’ was generally seen as a static fundamental attribute. Evolution was seen as gradual, making life/ecosystems more efficient, stable, and complex. Stability was the norm, with shocks/cycles exogenous. Equilibrium analysis was dominant. Ecology might be ‘solved’. In sharp contrast, now, fitness is regarded as frequency and context-dependent, and transient. Evolution is regarded as punctuated, not globally optimal. Complex ecosystems could be fragile with no real (long-term) equilibria. The focus now is on emergent dynamics, multiple attractors, and stochasticity. Spatial locality and mobility are seen as key issues. There has also been a data revolution in genetics and in remote sensing. Similarly in epidemiology, forty years ago, the emphasis was on aggregate (equilibrium) deterministic models. Now, non-equilibrium, stochastic models, and more rigorous inference are used. In common with ecology, current motifs are heterogeneity, location and mobility, evolutionary change, networks, control policy, behavioural responses, and simulation, often in agent-based models. Seen from this perspective, much of macroeconomics of the last three decades looks quite dated. Neil Ferguson also raised some specific questions on the presentation. For example, he asked

whether liquidity hoarding might have more to do with global confidence than network related local interactions, and whether models of imperfect information might have been underplayed in these banking network models. More generally, he expressed surprise at the focus of much of economics on analytical tractability as opposed to more data-based approaches incorporating individual heterogeneity.

Sujit Kapadia acknowledged that confidence and network interactions were both at work. The question was raised: was there a ‘representative bank’ model where the system behaved similarly with just one bank and an appropriate net balance sheet? The answer: ‘no’. It was argued that higher capital requirements would solve many stability problems, and at far less cost than widely believed, though Kapadia argued for leverage limits and liquidity standards as well, but with simple rules. It was argued that liquidity ratios give central banks time to respond to potential crises. Outcomes were very dependent on the precise rules of the game. One concern was that dynamic provisioning could cause complex dynamics, which could be sometimes problematic. What was known about the stochastics and distributions of potential outcomes in network models?

David Hendry (INET@Oxford Martin School)

posed five problems which confound the choice between alternative modelling approaches. First, macroeconomic theories are incomplete, incorrect and changeable; second, macroeconomic time-series data are aggregated, inaccurate and rarely match theoretical concepts; third, empirical macro-econometric models are non-constant, and mis-specified in numerous ways; fourth, economic policy often has unexpected effects different from prior analyses; and lastly, macroeconomic forecasts regularly go awry. Currently, the main justification of empirical macro-econometric evidence is conformity with conventionally-accepted economic theory: ‘internal credibility’, and this is partly justified by the manifest inadequacy of short, dependent, and heterogeneous time-series data, often subject to extensive revision: if data are unreliable, better to trust the theory. But theories have evolved greatly, and most previous analyses have been abandoned so he asked why we should trust mutable theory more than data evidence, seeking ‘verisimilitude’?

Widespread worries in the econometrics profession concern the prevalence of non-stationarity, endogeneity, potential lack of identification, and collinearity, supporting the belief that ‘data mining’ can produce almost any desired result. He noted that theory choice frequently does the same, by matching suspect ‘stylized facts, that are neither constant nor facts. There is also a mistaken conflation of economic-theory models of human behaviour with the data generation process (DGP) when there is often a huge gap between abstract theory and non-stationary evidence. Finally, there is a widespread but false belief that data-based model selection is a subterfuge of scoundrels—rather than the key to understanding the complexities of macro-economies. First, he outlined new methods for statistically rigorous data-based model selection, whereby a theory-model could be embedded in a general search process. When the theory-model was correct, its parameter estimates were unaffected by selection over other candidate variables, but otherwise an improved specification would be selected. He then turned to the pervasive problems caused by location shifts, where the means

of variables' distributions shift systematically. It was the primary cause of forecast failure, for example in VectorAutoRegressions, DSGEs, Equilibrium Correction Models, and in much of financial econometrics.. He argued that though prediction is then difficult, failure can be mitigated by robust devices and forecasters can deal with modelling failure while still figuring out what has gone wrong. He noted that location shifts invalidate the law of iterated expectations applied to inter-temporal analysis, so DSGEs are non-structural because their very mathematical basis fails when shifts like the financial crisis occur. Moreover, 'rational expectations' are systematically biased after shifts, yet agents can find it hard to learn what had changed. He illustrated this last implication in the context of the New Keynesian Phillips curve: when location shifts are taken into account, the role of expected inflation is radically diminished and there is little inflation persistence.

The discussant, **Kevin Hoover (Duke)**, placed these issues of empirical economics in the historical context of JS Mill's 1844 argument for theory over data, Haavelmo's *The Probability Approach in Econometrics* one century on, and the later post-Cowles Commission view that 'theory proposes; econometrics disposes'. He outlined his view of the Hendry methodology. These included a focus on facts rather than stylised facts, and on an adequate stochastic specification to be able to interpret statistics without too literal a connection to economic theory. The overall long-term strategy is a 'progressive' one of improving theories by learning from the data. This goes against the widespread assumption in economics that we know almost everything except some parameter estimates. The 'encompassing principle' of formulating a general enough stochastic specification to encompass a number of theories as testable special cases, and checking to see if one theory can explain another empirically, is the background to the general-to-specific model selection principle that David Hendry has long espoused, and which is increasingly supported by new findings in probability theory. If one defines risk as 'known unknowns' and uncertainty as 'unknown unknowns', the prevalence of the latter undermines the practical usefulness of the rational expectations hypothesis. Step and impulse-indicator saturation are powerful techniques for learning ex-post about changing distributions, as well more generally for specification search. Kevin Hoover also noted challenges for future work, for example, where theory implies complex consequences for use of data beyond inclusion/exclusion or sign restrictions, or where there are implications for systems of equations.

The wider discussion asked about fat tails vs. shifts in distributions. Hendry suggested that to distinguish systematic breaks from measurement error or outliers typically needs at least 3 observations, and is more easily done with high frequency data.

John Beath (St Andrews) summarized the results of the UK's Benchmarking exercise in relation to teaching undergraduate macroeconomics. The core elements in the curriculum should include the main trends in macroeconomic variables and how to find appropriate data; a macroeconomic modelling framework (general equilibrium with dynamics incorporating the real and financial sectors and the open economy); and the analysis of policy in response to a variety of shocks. He suggested that the short and medium-run analysis be dealt with first, with growth coming in more advanced courses.

The discussant, **Wendy Carlin (University College, London)**, put forward a concrete proposal for a new undergraduate macroeconomics curriculum that would meet the needs of students in the post-crisis era. She noted that only a tiny minority of economics students go on to do research in macroeconomics. In this light, an important aim of the undergraduate curriculum should be to teach students to communicate clearly about important economic performance and policy questions with non-economists. Although instructors and textbooks have to some extent responded to the crisis, this has typically amounted to *adding* topics on QE to the monetary policy section; debt dynamics, and fiscal consolidation to fiscal policy; and providing a descriptive account of the credit crunch and great recession. These new topics have been added to the existing diet of a variety of models: IS/LM; Aggregate Demand/Aggregate Supply or 3-equation model; Mundell-Fleming in the open economy, models of unemployment and an introductory treatment of the Real Business Cycle and New Keynesian models. She proposed a different response that would be based on teaching a single integrated model that can be used to explain how the economy works in good and bad times, where the general case is of an economy that is not self-stabilizing and where the objectives of the policy maker are explicit. A major innovation is to integrate the financial sector in the core macro model. The general framework model is the 3-EQUATION MODEL + FINANCIAL SECTOR, where the same model is used for the open and closed economies. It is presented in a new book co-authored with David Soskice (forthcoming, 2013).

The discussion touched on how the proposed Carlin–Soskice integrated model (3-EQUATION MODEL + FINANCIAL SECTOR) related to a New Keynesian DSGE+ model. There were some suggestions about how agent-based modeling might make a contribution to the curriculum but the view seemed to be that the work was at too early a stage to be suitable for the core curriculum. A number of comments highlighted a concern that growth and distribution were being neglected (in the presentations) and that both short-medium-run macro and growth were core components.

Roundtable: what new data does macro need?

Bernhard Winkler (European Central Bank)

concentrated on the flow of funds, relating it to new and old issues in the study of interaction of the financial sector and the real economy. Among the new, he cited work at the Bank of International Settlements on financial imbalances and credit cycles, Huyn Shin on financial intermediation chains, securitisation and leverage targeting broker-dealers, Muellbauer on credit liberalisation and household balance sheets for consumption. Among the old, liquidity trap (Keynes), portfolio balance (Tobin), debt deflation (Fisher), preferred habitat (Modigliani) and the role of money and credit for inflation and asset prices (Friedman, Brunner & Meltzer) had not gone away despite representative agents DSGE and inflation targeting. Most obviously, the flow-of-funds matrix and sectoral accounts offer an integrated framework to examine real and financial transactions, flows and balance sheets, and sector articulation, and to track the shifting role of financial intermediation and new institutional development. The ECB has put in place statistics on non-bank financial intermediaries

including Money Market Funds (MMFs), Investment Funds (IFs), Financial Vehicle Corporations (FVCs) and Insurance Corporations and Pension Funds (ICPFs). He illustrated some uses of FoF accounts by highlighting differences in financial surplus/deficits by sector for the Eurozone, differences by regions, and differences in sectoral debt to GDP ratios of Europe and the US. An analysis of fluctuations in sectoral leverages in the Eurozone illustrates the sectoral linkages and consequences of ‘disorderly’ attempts to reduce debt, which reduce asset values even more. For analysing macro-financial risk exposure, the FoF will prove even more central when the data improvements in progress are fully implemented.

Liz Dixon Smith (Bank of England) concentrated on financial stability and quoted the Office of Financial Responsibility: *“The lack of high quality, consistent and accessible data was a key source of risk in the financial crisis. [...] The lack of consistent and high quality data not only exacerbated the build up of risks, it also limited the ability to act decisively in the crisis”*. A 2009 report by the Financial Stability Board and IMF, endorsed by the G20 in November 2009, had already raised the alarm on data gaps that the financial crisis exposed, regarding build-up of risk in the financial sector, cross-border financial linkages, vulnerability of domestic economies to shocks and improving communication, and made twenty recommendations on data gaps that needed to be filled. The UK’s Financial Policy Committee requires data not only to identify risks, but to make and implement decisions, monitor, enforce, understand and communicate the impacts of its actions. Liz Dixon Smith discussed some of the issues of defining the institutional/legal building blocks and the networks of nodes and links between them, data standardisation, relevance for forward-looking financial resilience, and merging, aggregating and sharing data, which she suggested was a major new way of thinking about data.

Martin Weale (Monetary Policy Committee) argued that the quality of business and consumer surveys had not improved for many years and could be greatly improved by making them panels and examining *changes* of views by given respondents. Matching to better sampling frames such as the Interdepartmental Business Register and the Monthly Production Inquiry would also increase reliability. Data were particularly poor for the construction sector. Research suggested that survey results were affected by volatile collective sentiment as well as by the individual circumstance of each firm, so that systematic econometric research was needed to best interpret the data.

Neil Ericsson (Federal Reserve Board) pointed to the need to combine empirical methods and data that improved early warning of potential problems, could detect problems rapidly, lead to timely policy responses, and help avoid similar problems in the future. Desirable features of a centralised evolving data base included coverage and frequency, accessibility and ease of use, timeliness and accuracy and the capability of preserving vintage data when data were subject to later revision. The Federal Reserve Economic Data (FRED) maintained by the St Louis Federal Reserve illustrated many of these desirable features. It now included over 61,000 series from 46 national, international, public and private sources from which users can simply download data files. New data are uploaded usually within an hour of their release. Archives of vintage data are provided. FRED seeks users’ feedback, and is aggressively expanding its collection now increasingly used for academic teaching. It has

many benefits: transparency, accountability, information distribution with ease of ‘single-stop data shopping’, all of which have led to wide-spread analysis of FRED data with positive externalities for policy makers. He suggested the UK had much to learn from FRED, and that there was a need for ESRC and Government involvement to bring about similar improvements in UK data provision. One option might be to join FRED as a satellite.

John Muellbauer (INET@Oxford Martin School) argued that the current level of uncertainty about UK macro data was the largest in 40 years. The government’s decision to relocate the Office of National Statistics to Newport, South Wales had led to the departure of 80% or more of the most experienced national accounts staff and the loss of institutional memory. But even before relocation, there was little interest in the upkeep of long historical series of at least approximate consistency. For example, no historical series on the mortgage interest rate can be found on the ONS (or Bank of England) website, although two types of building society, and later building society/bank mortgage rates used to be published. In comparison with the US Bureau of Labor Statistics, which publishes hundreds of producer price indices broken down by sector and type, there are no historical series on the website of UK equivalents, except at the most aggregate levels. As noted by Neil Ericsson, easy-access FRED and government agency data bases have resulted in a vast amount of research on US data both inside and outside the US, creating a large positive externality for the US of this public investment in data provision. Lack of interest in macro empirical evidence by BOE and HMT is one explanation for UK data failure. Yet, the UK’s small open economy subject to large shocks should reduce many problems of endogeneity and multi-collinearity arising in US data, which **should** make UK data very desirable for empirical research!

He agreed with Bernhard Winkler on the need for good Flow of Funds accounts where again the US leads in household balance sheet and flow data, quarterly since 1952. UK data exist back to 1963, but the quality is often inadequate. For many countries, the situation is even worse: data on housing and mortgage markets are missing or poor, for example for household sector ownership of housing wealth, mix-adjusted house price indices, and the mortgage stock, let alone characteristics such as loan to value and loan to income, debt maturity etc., needed to track country differences or financial innovation/changes in institutions. Moreover, the dominance of ‘know-it-all macro’ without credit frictions contributed to a lack of interest in survey data on bank lending standards (the BOE’s began only in 2007) and house price expectations. Expectations of house and land price changes play critical roles in understanding fluctuations in house prices and house building. Overvaluation of house prices can arise because of extrapolative expectations after recent rises and because of fragile/unsustainable fundamentals. For example, in the US in 2004–5, his research with John Duca and Anthony Murphy at the Dallas Federal Reserve suggested an overvaluation of the order of 35% due to extrapolative expectations. Regular monitoring of expectations from surveys would have warned of over-optimism. The ONS surveyed house price expectations in occasional snapshot surveys in the 1990s, but not since.

Joe Grice (ONS) questioned the inference that ONS data quality had deteriorated as a result of ONS relocation. He too put high priority on improvements in Flow of Funds data and discussed a number of areas where improvements were in train.

Among points raised in the general discussion, were the need for ‘Big Data’ initiatives, bringing a data revolution to economics of the kind that had benefited ecology and epidemiology, as noted by Neil Ferguson earlier. The release for research purposes of micro data from administrative records, as in Denmark, was regarded as particularly important for agent-based modelling.

Biographies of the Speakers, Discussants and Chairpersons



Adrian Alsop holds a degree in Economics and has been with ESRC since 1989 in a variety of roles including: committee secretary, corporate policy and theme co-ordinator. As Director for Research, Partnerships and International Directorate he is responsible for the development, commissioning and impact of the Council’s research agenda within the Council’s three priorities of Economic Performance and Sustainable growth, Influencing Behaviour and Informing Interventions and a Vibrant and Fair Society. Adrian has developed partnerships with sister Research Councils, the Technology Strategy Board (TSB), government departments, business and civil society organisations. These include the Enterprise Research Centre with BBA and BIS, the Innovation Research Centre with BIS, TSB and NESTA and the Dementia Initiative with the Department of Health. Adrian is a member of the RCUK Research Group (RG) which leads the strategy for RCUK research programmes- ESRC is involved in all 6 RCUK programmes- and provision for capital spend, including the new Birth Cohort “Life Study”.



Seppo Honkapohja, D.Soc.Sc., has been a Member of the Board of the Bank of Finland since 1 January 2008, with responsibility for research, investment of financial assets and the administration function. Dr Honkapohja joined the Bank of Finland from the academic world. He was Professor of International Macroeconomics at the University of Cambridge in 2004–2007. His prior career included work with the Academy of Finland, University of Helsinki and Turku School of Economics and Business Administration.

Mark Gertler is the Henry and Lucy Moses Professor of Economics at New York University and a Research Associate at the National Bureau of Economic Research. He received his Phd. at Stanford University. He has published widely in macroeconomics and monetary policy, including nearly a dozen articles with Federal Reserve Chairman Ben Bernanke. The Institute for Scientific Information lists him as a “Highly-Cited Researcher in Economics.” Gertler also serves as an academic consultant for the Federal Reserve Bank of New York and is a Co-Editor of the *American Economic Review*. He was formerly Chairman of the economics department at NYU and also formerly Director of the C.V. Starr Center for Applied Research. Among professional

honours, Gertler is a Fellow of the Econometric Society, a Guggenheim Fellow, and a Fellow of the American Academy of Arts and Sciences.



Simon Wren-Lewis is a professor at Oxford University and a Fellow of Merton College. He began his career as an economist in H.M.Treasury. In 1981 he moved to the National Institute of Economic and Social Research, where as a Senior Research Fellow he constructed the first versions of the world model NIGEM. From 1988-1990, as Head of Macroeconomic Research, he supervised development of this and the Institute's domestic model. In 1990 he became a professor at Strathclyde University, and built the UK econometric model COMPACT. From 1995 to 2006 he was a professor at Exeter University. He has published papers on macroeconomics in a wide range of academic journals including the Economic Journal, European Economic Review, and American Economic Review. His current research focuses on the analysis of monetary and fiscal policy in small calibrated macro-models, and on equilibrium exchange rates.



Ricardo A. M. R. Reis is a professor of economics at Columbia University. Originally from Portugal, he received his B.Sc. degree from the London School of Economics in 1999, and his Ph.D. from Harvard University in 2004. He taught previously at Princeton University, and is currently a Research Associate of the National Bureau of Economic Research (Cambridge, Mass.), a Research Fellow of the Centre for Economic Policy Research (London), a co-editor of the Journal of Monetary Economics, a member of the Board of Editors of the American Economic Review and the Journal of Economic Literature, and an associate editor of the Economic Journal and the Journal of Money, Credit and Banking. His main area of research is macroeconomics, both theoretical and applied. Some of his past work has focused on theories of inattention and models of sticky information in which news diffuses slowly in the population leading to disagreement among consumers, price-setters and workers, which induce sluggish reaction of macroeconomic variables to shocks. He has also worked extensively on inflation dynamics, including the construction of better measures of inflation and an accurate measurement of inflation's properties. Finally, he has also made several contributions to the study of monetary and fiscal policy, including studies of unconventional monetary policy, and evaluation of fiscal stimulus programs.



Bartosz Maćkowiak is Senior Economist in the Directorate General Research at the European Central Bank. He holds a Ph.D. in Economics from Yale University. Prior to joining the ECB in 2007, Bartosz was a faculty member at Humboldt University in Berlin. His research focuses on macroeconomics, econometrics, and information economics.



Katarina Juselius is Professor at University of Copenhagen, Economics Department and is one of Denmark's leading scientists with specialisation in the methodology and applications of Co-integrated VAR models. She has published

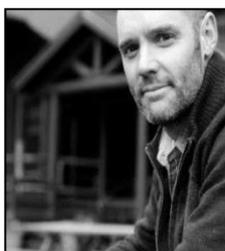
extensively in international peer reviewed journals, has been invited to write handbook chapters, and is one of the top cited economists in the world. She is also an active member of the scientific community and has been a member of several scientific councils and advisory committees in Denmark and abroad and is a former Chair of the EuroCore and Forward Look Programmes at the European Science Foundation and the Danish Independent Research Council for the Social Sciences. She is presently the director of the INET Centre of Imperfect Knowledge Economics at the University of Copenhagen.



Viral V. Acharya is the C.V. Starr Professor of Economics in the Department of Finance at New York University Stern School of Business (NYU-Stern) and the current PhD coordinator in the Finance department at Stern. He is currently associate editor of the *Journal of Finance* (2011-), *Review of Corporate Finance Studies* (RCFS, 2011-) and *Review of Finance* (2006-), and was an editor of the *Journal of Financial Intermediation* (2009-12). Viral's primary research interest is in theoretical and empirical analysis of systemic risk of the financial sector, its regulation and its genesis in government-induced distortions, an inquiry that cuts across several other strands of research – credit risk and liquidity risk, their interactions and agency-theoretic foundations, as well as their general equilibrium consequences. He is co-author of the book *Guaranteed to Fail: Fannie Mae, Freddie Mac and the Debacle of Mortgage Finance*, Princeton University Press, March 2011 and Harper Collins (India), June 2011.



Martin Ellison is a British [economist](#). He is currently Professor of economics at the [University of Oxford](#) and Michael Cohen Fellow of Exeter College. He gained his [PhD](#) in economics in 2001 from the [European University Institute](#) in [Florence](#). Martin has worked as a consultant for the [Bank of England](#) and as a Professor at the [University of Warwick](#) before his current affiliation at the University of Oxford. He is specializing in [macroeconomics](#); his PhD thesis was named "*Money Matters: Four Essays on Monetary Economics*". His main research interest is monetary policy and he is currently editing several journals in the field of economics.



Scott E. Page is the Leonid Hurwicz Collegiate Professor of Complex Systems Political Science, and Economics at the University of Michigan, where he also directs the Center for the Study of Complex Systems. In 2011, he was elected to the American Academy of Arts and Sciences. His research focuses on the myriad roles that diversity plays in complex systems. For example, how does diversity arise? Does diversity make a system more productive? How does diversity impact robustness? Does it make a system prone to large events? Scott has written three books: *The Difference*, which demonstrates the benefits and costs of diversity in social contexts, *Complex Adaptive Social Systems* (with John Miller), which provides an introduction to complexity theory, and, most recently, *Diversity and Complexity*, which explores the contributions of diversity within complex systems. He has also published papers in a variety of disciplines including economics, political science, computer science,

management, physics, public health, geography, urban planning, engineering, and history. In addition to writing papers and books, he has filmed a video course on complexity called *Understanding Complexity*.



Domenico Delli Gatti is Professor of Economics at Università Cattolica, Milan. He has published extensively (around 50 articles) in refereed journals and is the author or co-author of three books. In the period 2000-2011, he was the coordinator of the European research project "Monetary, Fiscal and Structural Policies with Heterogeneous Interacting Agents" (POLHIA) (www.polhia.eu) and since November 2011 he has been one of the coordinators of "Complexity Research Initiative on Systemic Instabilities" (CRISIS) (www.crisis-economics.eu), together with Doyne Farmer. Both research projects have been financed by EC under the FP7. His most recent book is "Macroeconomics from the Bottom Up" published by Springer Verlag.



Paul Tucker was appointed as Deputy Governor, Financial Stability in March 2009. He is a member of the Bank of England's Monetary Policy Committee, Financial Policy Committee and Court of Directors. He was appointed chair of the Committee for Payment and Settlement Systems in April 2012. He is a member of the G20 Financial Stability Board Steering Committee, and chairs the Financial Stability Board's group on resolving large and complex banks. From June 2002 until Paul's current appointment, Paul was Executive Director for Markets.



Philippe Moutot was appointed Deputy Director General of the Directorate General Economics of the European Central Bank on 1 July 1998. The Directorate General Economics is responsible for the preparation of monetary policy decisions of the ECB. It is also responsible for analysis of and studies on economic and financial developments and policies inside and outside the euro area. Since February 2005 he has been also Director of the Monetary Policy Directorate. Within the Directorate General Economics, the Directorate Monetary Policy is responsible for the analysis and regular assessment of the monetary policy strategy and of the appropriateness of the monetary policy stance; the preparation of monetary policy decisions and the monitoring and analysis of the financial systems of the euro area. From November 1994 to June 1998, Philippe Moutot was Head of the Stage Three Division of the European Monetary Institute. This division was responsible for helping define the concepts, framework and rules for the Single Monetary Policy in Stage Three of EMU. Originally a civil engineer from the Ecole Nationale des Ponts et Chaussées, Philippe Moutot also holds a Ph D in Economics from the University of Chicago and a diploma from the Paris Institut d'Études Politiques.

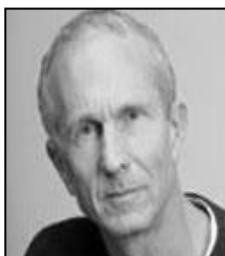


John Muellbauer is an applied macroeconomist. His 1980 paper with Deaton, 'An Almost Ideal Demand System' in the American Economic Review was selected as one of the top twenty papers published in the first one hundred years of that journal. His current research aims to achieve a better understanding of interactions between the financial sector and the real

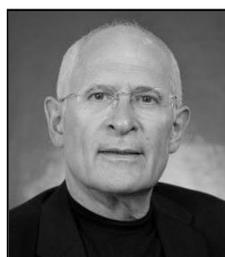
economy. A major element is to study the impact of credit market liberalization on consumer debt, spending and housing markets in the UK, US, Australia and in Europe and non-liberalisation in Japan to throw new light on monetary transmission, financial stability and monetary policy. Closely related is investigating the determinants of mortgage defaults in the UK, and examining forecast scenarios relevant to stress-testing of the banking system. Other recent research has been on inflation forecasting and exchange rate pass-through. He is Professor of Economics and a Senior Fellow of the Institute for New Economic Thinking at the Oxford Martin School, Oxford University and a Fellow of the British Academy, of the Econometric Society, of the European Economic Association, a CEPR Research Fellow and currently a Wim Duisenberg Visiting Fellow at the ECB.



Jean-Philippe Bouchaud was born in France in 1962. After studying at the French Lycée of London, he graduated from the Ecole Normale Supérieure in Paris, where he also obtained his PhD in physics. He was then appointed by the CNRS until 1992. After a year spent in the Cavendish Laboratory (Cambridge), he joined the Service de Physique de l'Etat Condensé (CEA-Saclay), where he worked on the dynamics of glassy systems and on granular media. He became interested in economics and theoretical finance in 1991. His work includes extreme risk models, agent based models, market microstructure and price formation. He has been very critical about the standard concepts and models used in economics and in the financial industry. He founded the company Science & Finance in 1994 that merged with Capital Fund Management (CFM) in 2000. He is now the Chairman and Head of Research at CFM, and professor at Ecole Polytechnique since 2008. He was awarded the IBM young scientist prize in 1990 and the C.N.R.S. Silver Medal in 1996. He has published over 250 scientific papers and several books in physics and in finance.



Doyne Farmer co-directs the programme on complexity economics, which is part of the [INET@Oxford](#) research institute. He has broad interests in complex systems, and has done research in dynamical systems theory, time series analysis and theoretical biology. His main interest is in developing quantitative theories for social evolution, in particular for financial markets (which provide an accurate record of decision making in a complex environment) and the evolution of technologies (whose performance through time provides a quantitative record of one component of progress).



Richard Portes is Professor of Economics at London Business School (since 1995) and President of the Centre for Economic Policy Research (which he founded in 1983). He was Directeur d'Etudes at the Ecole des Hautes Etudes en Sciences Sociales in Paris (1978-2011), a Rhodes Scholar and a Fellow of Balliol College, Oxford, and has also taught at Princeton, Harvard (as a Guggenheim Fellow), and Birkbeck College (University of London). In 1999-2000, he was Distinguished Global Visiting Professor at Haas Business School, University of California, Berkeley, and in 2003-04 he was Joel Stern Visiting Professor of

International Finance at Columbia Business School. Richard is a Fellow of the British Academy and of the Econometric Society. He was decorated Commander of the British Empire (CBE) in the Queen's Honours List 2003. He is Co-Chairman of *Economic Policy*, a member of the Bellagio Group on the International Economy and of the Council on Foreign Relations. He writes and speaks widely on international macroeconomics and finance: the global financial crisis, international currencies, financial regulation, macroeconomic imbalances, the euro and European integration, sovereign debt. He was the first to examine the international role of a single European currency (*European Economy*, 1991). He returned to this in 'The

Emergence of the Euro as an International Currency' (*Economic Policy*, 1998), then in 'The International Role of the Euro' (*European Economy Economic Papers*, April 2008). He and Barry Eichengreen wrote *Crisis? What Crisis?* (CEPR, 1995), which proposed the collective action clauses in sovereign bond contracts that have since become standard. His work with H el ene Rey on cross-border equity flows (*JIE* 2005) introduced gravity models into the study of capital flows. In February 2009 he co-authored *Macroeconomic Stability and Financial Regulation* (CEPR and VoxEU).



Sujit Kapadia is a policy advisor on the Financial Policy Committee Secretariat at the Bank of England. He takes a lead role in the design and specification of the Bank's new macro-prudential policy framework – with a particular focus on the suitability and functioning of different macro-prudential instruments – and has been involved in a range of regulatory policy design work at an international level. He has also conducted extensive research on analytical and network models of systemic risk, financial crises and contagion, and worked on the design of stress testing models. Prior to joining the Bank in 2005, Sujit completed a PhD in economics at the University of Oxford.



Neil Ferguson, OBE FMedSci, is founding director of the MRC Centre for Outbreak Analysis and Modelling and Head of the Department of Infectious Disease Epidemiology at Imperial College London. He uses mathematical and statistical models to investigate the processes shaping infectious disease pathogenesis, evolution and transmission. In addition to some basic theoretical work, Professor Ferguson's research has applied models to study the transmission and control of influenza, SARS, BSE/vCJD, HIV, dengue, foot-and-mouth disease and bioterrorist threats. He was educated at Oxford University and held a Royal Society University Research Fellowship at Oxford before moving to Imperial College. Professor Ferguson is an NIHR Senior Investigator, a Fellow of the UK Academy of Medical Sciences and received an OBE in 2002 for his work on the 2001 foot and mouth disease epidemic. His recent work has focussed on the use of mathematical models as contingency planning tools for emerging human infections (notably pandemic influenza), bioterrorist threats and livestock outbreaks (FMD and avian influenza), though he also undertakes research on the dynamics and control of vector-borne diseases (dengue, yellow fever and malaria) and pathogen evolution. Prof Ferguson has sat on multiple UK government scientific advisory bodies, and also advises the US government, the World Health Organisation and the European Union. Recently he was heavily

involved in providing real-time analysis and scientific advice during the 2009 H1N1 pandemic.

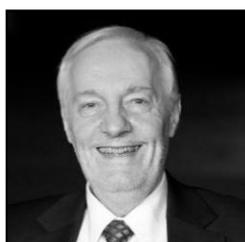
David F. Hendry, Kt, is Professor of Economics, Fellow of Nuffield College, and Director, Program in Economic Modeling, Institute for New Economic Thinking at the Oxford Martin School, University of Oxford. He was previously Professor of Econometrics, London School of Economics. He was Knighted in 2009; is an Honorary Vice-President and past President Royal Economic Society; Fellow, British Academy, Royal Society of Edinburgh, Econometric Society and *Journal of Econometrics*; Foreign Honorary Member, American Economic Association and American Academy of Arts and Sciences; Honorary Fellow, International Institute of Forecasters. He has received seven Honorary Doctorates as well as the Guy Medal in Bronze from the Royal Statistical Society. He is listed by the ISI as one of the world's 200 most cited economists, and has published more than 200 papers and 25 books on econometric methods, theory, modelling, and history; numerical techniques; computing; empirical economics; and forecasting.



Kevin D. Hoover is Professor of Economics and Philosophy at Duke University. He is the author of the *New Classical Macroeconomics: A Sceptical Inquiry*, *Causality in Macroeconomics* and *The Methodology of Empirical Macroeconomics*, and most recently of a textbook, *Applied Intermediate Macroeconomics*. He is a past editor of the *Journal of Economic Methodology* and current editor of *History of Political Economy*. His research interests include monetary and macroeconomics, casual and specification search algorithms and their applications, the epistemological and logical foundations of econometrics, and the history of macroeconomics.



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Professor John Arnott Beath studied at the Universities

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Bernhard Winkler was born in Bonn, Germany. He studied Economics and Political Science at the University of Trier, holds an M.Phil. in Economics from the University of Oxford (1993), visited UC Berkeley in 1994-5 and received a PhD. from the European University Institute, Florence in 1997. He worked at the Deutsche Bundesbank before joining the European Central Bank's Directorate-General Research as economist in July 1998. Subsequently he held positions as Senior Economist in the Monetary Policy Strategy Division, in the Counsel to the Executive Board as adviser to Prof. Otmar Issing, and since May 2005 as Senior Adviser in the Directorate Monetary Policy responsible, inter alia, for flow-of-funds analysis at the ECB and the co-ordination of financial projections as part of the quarterly macroeconomic projections exercises. He has published on issues related to monetary and fiscal policy in a monetary union, on monetary policy communication and on the Stability and Growth Pact as well as on cross-checking and the flow of funds.



Liz Dixon Smith works in the Financial Stability area of the Bank of England. Her main area of interest is the data requirements for macroprudential policy. She

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Joe Grice has spent most of his career at the Treasury. His last two posts were as Director of Macroeconomic Policy (till 2000) and then as Chief Economist and Director of Public Services. Since 2007, Joe has been the Chief Economist at ONS, responsible for the production and interpretation of UK economic statistics. Joe chairs the OECD's Working Party on Macroeconomic and Structural Policy Issues and also the EU Committee on Monetary, Finance and Balance of Payments Statistics. He has been elected to the Council of the Royal Economic Society and is a visiting lecturer at the University of Cambridge.