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ABSTRACT

Monetary authorities have been implicated in the financial crisis of 2007-2008. John Muellbauer, for example, has blamed what he thought was initially inadequate policy responses by central banks to the crisis on their models, which are, in his words, "overdue for the scrap heap". This paper investigates the role of monetary policy models in the crisis and finds that (i) it is likely that monetary policy contributed to the financial crisis and (ii) that an inappropriately narrow suite of models made this mistake easier. The core models currently used at prominent central banks were not designed to discover emergent financial fragility. In that respect John Muellbauer is right. But the implications drawn here are less dramatic than his: while the representative agent approach to microfoundations now seems indefensible, other aspects of modern macroeconomics are not similarly suspect. The case made here is rather for expanding the suite of models used in the regular deliberations of monetary authorities, with new models that give explicit roles to the financial sector, to money and to the process of exchange. Recommending a suite of models for policy making entails no methodological innovation. That is what central banks do; though, of course, how they do it is open to improvement. The methodological innovation is the inclusion of a model that would be sensitive to financial fragility, a sensitivity that was absent in the run-up to the current financial crisis.

Keywords: Monetary policy, financial crisis, methodology of policy models
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Introduction

In October 2008, with the financial crisis worsening seemingly by the day, John Muellbauer (2008) asked "Why Europe's key central banks made this potentially catastrophic error..." and found "one reason...rests in their econometric models, based on fashionable but outdated economic theory". The widely used models, he continued, "were overdue for the scrap heap".

This is surprising talk indeed in light of the remarkable consensus that had developed on the theory and practice of monetary policy over the preceding 30 years (Goodfriend, 2007; Mishkin, 2007). So strong was the consensus that Stephen Grenville (2001) at the Reserve Bank of Australia wondered just a few years earlier whether the "history" of monetary policy - read in the tradition of Fukuyama's (1992) - had ended with inflation targeting; to his credit, he argued, no. But it is not just another application of Fukuyama that is wrong for critics like Muellbauer: not only is there a future beyond the consensus model, the consensus was itself deeply flawed.

The crisis has called into question: the goals of monetary policy (Morgan, 2009), the models used by central bankers (Muellbauer, 2009), the theory upon which they are based (Buiter, 2009), and even the perceived ideology of central bankers (e.g. Kaufman, 2009; Sachs, 2009). It is the criticism against the models used by monetary authorities and the methodological implications for such models that form the focus of this paper. These methodological implications are written in small caps (see, for example, Boland, 2001), they are about adapting existing models and suggesting new ones that work "better" (in ways defined below), and not about large questions in epistemology or the philosophy of science.

Prior to the crisis and despite the favourable assessment of monetary policy at the time, a number of small "m" methodological questions were considered open. The crisis has highlighted the importance of these questions and I will focus my attention here on those questions that are in some way directly related to the run-up or unfolding of the crisis. Specifically I will draw two methodological lessons: First, Muellbauer has a point, there are serious flaws with the current crop of core policy models and some new ones are needed; second, expanding the suite of models used by central banks to include some with the features described in this paper (including a prominent role for financial intermediaries) would have made it harder for the Fed and other banks to follow the policy path that preceded the crisis. This lesson holds whether you think that path was a substantial deviation from the consensus policy model (e.g. Taylor, 2009) or followed from a reasonable application of that model (e.g. Bernanke, 2010).

2. Monetary policy and asset markets

The Financial crisis that emerged in 2007 originated in the market for residential property in the United States, but soon spread to other asset markets in the US and internationally, eventually leading to a full-blown banking crisis that pushed economies around the world into the deepest recession many had seen in the Post-War era. The crisis was due to a compounding of errors in housing markets (in the US and elsewhere) and in the markets for derivative instruments[1].

Briefly, the crisis originated with an inappropriate investment strategy in residential property, compounded by financial market instruments that changed the nature of and obscured the associated risks, thereby weakening the balance sheets of highly geared financial institutions. A modern run-on-banks ensued in the interbank market and caused an international banking crisis with large output and employment losses (Almunia et al., 2009).

What role if any, did monetary policy play in (i) creating the environment for the crisis and (ii) allowing it to unfold? Starting with the housing market we can think of acts of omission and commission by especially the Federal Reserve Board (Fed) and other central banks that either encouraged the housing boom, or allowed it to run unchecked. Starting with acts of omission, these is little evidence that monetary authorities used policy instrument directly to contain the boom (which had both price and quantity aspects) in residential property. They were implementing the modern consensus - perhaps the most widely-known formulation is Bernanke and Gertler (1999) - that central banks should not respond *ex ante* to asset market fluctuations over and above the consequences of these fluctuations for the outlook on inflation and real output[2,3]. Financial stability and price stability is complementary under (explicit or implicit) flexible inflation targeting in this view (Bernanke and Gertler, 1999: 18, 22).

There are good reasons for not incorporating asset prices as a distinct objective of the interest rate policy of monetary authorities[4], including (Bernanke and Gertler, 1999; Goodhart, 2005; Blinder, 2005; Mishkin, 2007): first, the knowledge problem that central banks would have to identify unjustifiable asset price movements more accurately than the financial markets. For example, an important statement of the case for direct targeting of asset prices, by Genberg, Lipsky, Cecchetti and Wadhwani,

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[1] There are a number of excellent accounts of the crisis, such as Blanchard (2009) and Almunia, Bénétrix and Eichengreen (2009) and recently Roberts (2010) with a focus on the changes in financial sector incentives. The text focuses on those aspects most closely related to monetary policy and, consequently, misses a lot of the detail (especially of an institutional kind) in these broader accounts.

[2] This was one of the less widely shared notions in the modern consensus on monetary policy. Or to be more precise it was one of the elements of the consensus which many monetary economists and central bankers felt was more open to further research and experience (Goodfriend, 2005; Mishkin, 2007).

[3] Note that Bernanke and Gertler (1999) did not recommend policy paralysis, on the contrary they reasoned that "...asset price crashes have done sustained damage to the economy only in cases when monetary policy remained unresponsive or actively reinforced deflationary pressures" (Bernanke and Gertler, 1999: 18). And it seemed that the required response was precisely the response indicated by a flexible inflation targeting system.

[4] While "monetary policy" typically means the interest rate policy of a modern central bank, there are other instruments available to central banks, including reserve requirements, quantitative adjustments to the monetary base and usually a role in the regulation of financial sector firms (Borio and Disyatat, 2009).

(2000), assumed that the central bank knew when an asset market boom had turned into a bubble. That, however, is what central banks do not generally know, neither *ex ante* nor always even *ex post*.

Second, the volatility of asset prices and the tenuous link between the stance of monetary policy and asset market outcomes, risks undermining the credibility of the monetary authorities. Third, an important lesson of monetary policy in the 20th century was that more successful central banks focussed their attention narrowly on the "correct" objectives (such as price stability and stable real output around capacity) and did not get distracted by pursuing a myriad of goals. Targeting asset prices would undermine that focus of monetary policy by requiring contradicting policy adjustments depending on the nature of the shock to the markets. Finally, there are other instruments at the disposal of the central bank (or the government depending on institutional arrangements), such as financial regulations, that may be more suited to addressing the risks of asset price volatility.

Such was the consensus prior to the crisis, but the severity of the episode has encouraged revision of this "mop up afterwards" approach to asset bubbles[5] (e.g. Mishkin, 2008 and Blinder, 2008). A finer distinction is now being drawn between types of asset price bubbles, with the old consensus still applicable for bubbles on the stock market and where bank credit played a small part ("equity bubbles" in the terminology of Mishkin, 2008), but not for asset bubbles where the provision of cheap credit by banks play a central role ("credit bubbles" in the terminology of Mishkin, 2008).

In these credit bubbles neither the knowledge problem nor the instrument problem is likely to be as severe as suggested above, or so the argument goes. A central bank that also plays a role as bank regulator and supervisor has much better information about bank lending and potentially about the prudence of that lending[6] compared with knowledge about the fundamental support for stock market prices. And central banks have a range of regulatory powers that can be used to reign in credit lending that is supporting an asset bubble, instruments that act directly on the behaviour of banks.

This distinction is sensible and is a lens through which plausible *ex post* readings of cases such as the "Great crash" of 1929, the Japanese asset price boom and bust and the recent financial crisis have been offered by Mishkin (2008). But to act against credit bubbles requires an *ex ante* reading and there is not much evidence that the Fed (or other major Central Banks) were able to do that with respect to the recent crisis. Indeed, former Fed Deputy Governor Alan Blinder considered the risks to various dimensions of US monetary policy in August 2005 (when the credit bubble was well under way) and summarised his results in a risk management matrix. It indicated moderate risks to inflation, employment and aggregate demand and a high risk of a supply side shock. Crucially, he identified the

[5] Blinder (2005) argued that the "mop up" approach passed a "severe" stress test with the unwinding of the Dotcom bubble from 2000 to 2002.

[6] For Mishkin (2008) a prerequisite for taking policy action against even a credit bubble is that the bubble reflects market failure of some kind.

level of risk for both the banking sector and credit risk to be *low*, *stable* and covered by *strong* risk management (Blinder, 2005: Table 1).

It is the central argument of this paper that methodological changes are necessary to the models used in assessing monetary policy such an observer in Blinder's (2005) position would have identified the emerging credit and banking sector risks. Without these changes the distinction between credit and equity bubbles bring Central Banks no closer to a practical engagement with the risks of asset bubbles.

3. The "Great deviation"

If the Fed did not use the stance of policy to prevent the housing boom from accelerating, nor the associated development in the derivative markets, these events could still have been influenced by what the Fed did do. The Bernanke-Gertler consensus on the role for asset prices requires monetary authorities to care about asset prices to the extent that they affect the outlook for price stability and the output gap. But that is precisely what the Fed did not do from 2002 until 2006, according to the argument John Taylor has forcefully presented in a series of papers and summarised in Taylor (2009).

Between 2002 and 2006 the target Federal Funds Rate deviated further and longer from the path prescribed by the Taylor rule for any period since the 1970s; Taylor has called it the "Great Deviation"[7]. Taylor's argument is that the Federal Reserve board fuelled the housing boom, and the associated financial market gearing, by keeping interest rates too low for too long

What accounts for this "Great Deviation"? Poole (2007: 5) suggested that the Taylor rule as used for the 1980s and 1990s would not track the actual policy well after 2000 because (i) the Fed decided to use the Personal Consumption Expenditure price index (PCE) as the focus for it's deliberations on price stability at that time and (ii) decided to emphasise *core* PCE (excluding food and energy), as opposed to the headline index. To the extent that Core PCE inflation was lower than headline CPI inflation over this period Taylor's rule would not give an accurate description of systematic policy at the Fed.

This is an empirical argument and easily checked by comparing the interest rate recommended by the Taylor rule based on the CPI headline inflation with the same rule's recommend interest rate based on the Core PCE inflation. There is something in the Poole argument: using Core PCE (and the same Taylor rule specification) would have resulted in a lower recommended Fedfunds rate over this period, notably in 2005 and 2006. But this difference doesn't explain the pattern observed by Taylor, who observed deviations of 2-3% from the Taylor rule in 2002, 2003 and 2004, while the price index adjustment recommended by Poole would leave a gap of 0.5 to 1.5% over that period, rising to 2 tot 3% in 2005, i.e. when John Taylor found the gap between the policy rate and the Taylor rule closing

[7] William Poole – then chief executive of the Federal Reserve Bank of St Louis – observed the same in 2007 (Poole, 2007).

rapidly. Adopting Core PCE as opposed to CPI does not, therefore, explain the pattern of deviations observed by John Taylor.

The second term in the Taylor rule is the output gap and an analogous argument to Poole's might be used here to explain the observed path of the Fedfunds rate. Monetary authorities operate with considerable uncertainty about prevailing economic conditions, the transmission mechanism and as a combination of these with notable uncertainty about the likely future path of inflation, output and other variables of interest. The methodology of monetary policy can and does account for these sources of uncertainty[8]. If the current estimates of GDP over the relevant period is much higher than the contemporary estimates then the Taylor rule with current estimates would show a higher recommended interest rate path than would have been apparent at the time the policy decisions were taken. The same is true with respect to PCE inflation.

While Poole (2007) used real-time Congressional Budget Office estimates of the output gap when he identified the "Great Deviation" it is now possible to use the Green Book "nowcasts" of data used by the FOMC in real time policy making[9]. But the difference between the real-time and revised estimates of GDP for this period was unbiased (no systematic under or over-estimation) and provides no clue to the "Great deviation".

The same is not true of the gap between the real-time and revised PCE inflation data though. More specifically, Bernanke (2010) showed that using the real time *forecasts* of PCE inflation in a Taylor rule (as opposed to the revised historical data) accounts for almost the entire "Great Deviation". This argument is consistent with Fed communication of the period, when it was known to be concerned

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[8] The awareness of the data constraints under which policy is made in real time is hardly new, and the point has been made repeatedly in the post-War period, by, to name just a few: Friedman (1947), Meltzer (1987) and McCallum (1994) and more recently by Orphanides in a series of papers, including Orphanides (2002).
Two important lessons have emerged from this literature (Orphanides, 2002: 606): first, the evaluation of past policy must be sensitive to the data available in real time to the policy-makers. For the case at hand this means looking at the Fed's best estimates of output and inflation in the critical years between 2001 and 2005, not an evaluation of what seems optimal with the benefit of the revised data. Second, realistic policy alternatives have to be based on data that is both available and measurable with a high signal-to-noise ratio. From this perspective it is not useful to examine the merit of alternative policy paths in 2001 to 2005 based on the assumption that policy makers could have known that an asset bubble was emerging in the US housing market.
The quantitative importance of noise in the data on the merit of alternative policy paths was demonstrated through simulation by Orphanides (2002). He contrasts the substantial gains that appear within the grasp of an activist monetary authority when they operate with noiseless data, with the substantially inferior results generated by the same activism when the relevant data is noisy. Indeed with noise a much less activist policy rule delivers substantially better stabilisation for the economy. The same result, favouring a "conservative" central banker, emerges when the monetary authorities grapple not only with noisy data but with uncertainty about the transmission mechanism and expectations (Orphanides and Williams, 2008).

[9] These "nowcasts" are released with a 5-year time lag, allowing consideration of the critical 2002 to 2005 period at the time of writing.

with deflationary risks in the wake of the Dotcom bubble[10] (Svensson, 2009b), for example the following extract from the FOMC minutes of the meeting on 24-25 June 2003:

> [the members] considered aspects of the Committee's communications as a means of underscoring to the public its willingness to follow a sufficiently accommodative path of monetary policy for as long as necessary to foster improved economic performance… While considerable uncertainty surrounded each individual policy option, the members agreed that the effectiveness of these alternative tools, along with the 125 basis points of conventional easing still available, would allow monetary policy to combat economic weakness and *forestall any unexpected tendency for a pernicious deflation to develop*. (Board of Governors of the Federal Reserve System, 2003, my emphasis).

The gap between Taylor's calculation and that of Bernanke's does indicate that the Fed systematically underestimated the risk of PCE inflation over this period though, which reflects negatively on the Fed's models and the way they were used at the time. But that is not the methodological point at stake here. Rather the question is whether the models used by the Fed and other Central Banks were unduly insensitive to potential asset market disruptions during a period in which their models, the FOMC meeting and informed commentators such as Blinder (2005) did not foresee the emerging risks?

The connection between an accommodating monetary policy and a boom in the housing market was explored by both Ed Leamer (2007) and John Taylor (2007) at the Kansas City Fed's Jackson Hole symposium in 2007. Using different methods, they arrived at the same conclusion, i.e. that the Fed, fearing deflation, had contributed to a housing boom in the period 2002 to 2006 by keeping interest rates lower than they would have been under normal circumstances. And broader evidence, presented by Ahrend, Cournède, and Price (2008) for the OECD countries as a group supports the same hypothesis, i.e. low interest (lower than suggested by Taylor rules for the individual countries) contributed significantly to booms in residential property internationally.

A connection between the stance of monetary and a housing bubble is insufficient though as the magnitude of the crisis cannot be understood without understanding the increased leverage of banks and other financial institutions (Blanchard, 2009). While low interest rates helped to finance the housing boom more cheaply, recent theoretical work suggests that low interest rates might also increase leverage in the financial sector along two channels (Borio and Zhu, 2008; Adrian and Shin, 2009): first the low nominal returns on cash might encourage financial firms to pursue higher yielding (and more risky) investments; this is especially relevant for financial firms who are contracted to deliver a given

[10] John Muellbauer (2007) argued that the Fed's concern with the risk of deflation was a misplaced fear that the Japanese episode of the 1990s could be repeated in the USA.

nominal return. Second, the effect of low interest rates on asset prices and cash flows might allow financial firms to carry more risky investments while their balance sheets will appear sound.

Gambacorta (2009) investigated the empirical relevance of these hypotheses for the current crisis and more generally for Europe and the USA with a database of 600 listed banks. His empirical results suggest that the period of low interest rates discussed here contributed importantly to higher risk taking at European and American banks[11].

An interim conclusion at this point is that monetary policy contributed in two ways to the financial crisis: first, discretionary lower interest rates fuelled a boom in housing market internationally, and especially in the USA. Without this boom it is hard to envisage the crisis as it actually unfolded. Second, the increased leverage in the financial sector, which magnified the effect of the crisis far beyond the size of sub-prime market, was also related to low interest rates that encouraged investment banks and other financial institutions to adopt ever more risky investment strategies. The puzzle is why the models of the economy used by the Central Banks did not alert them to these risks *ex ante*.

4. What role for monetary models in the crisis?

A remarkable consensus developed on the theory and practice of monetary policy since the 1970s. In practice this consensus is seen in the rise of explicit and implicit flexible inflation targeting (Goodfriend, 2005; Svensson, 2006), a system whereby a central bank aims at stabilising inflation around a low numerical target, while giving some weight to output fluctuations in its objective function. This is a forward-looking approach to monetary policy - often called forecast targeting - in which expectations play a critical role. This forward-looking approach in practice reflects the influence of rational expectations models and their implications for credibility and commitment (Goodfriend, 2005).

Theoretically the consensus model, a New-Keynesian model, is a dynamic general equilibrium model built around a real business cycle core, with rational expectations and price stickiness (Goodfriend, 2005). A popular heuristic unfolds the model in three equations (Clarida et al., 1999; Goodhart, 2005), though the actual implementation in policy models sees various extensions and elaboration. The first equation of the consensus model expresses the relationship between real expenditure on one side and monetary and other shocks on the other, i.e. it is the modern forward-looking version of an IS relationship[12]. This part of the model has substantial empirical support (Goodhart, 2005: 4).

[11] There were many other factors such as regulatory mistakes or even "holes" in financial regulation as well as psychological factors such as overoptimism that played a role in the increased leverage and perverse incentives that encouraged risk taking in the banking sector (Blanchard, 2009; Roberts, 2010).

[12] Models used by central banks in the policy process will usually disaggregate this IS relationship in a number of constituent relationships by different types of real expenditure (Goodhart, 2005: 3-4).

Aggregate supply in the model is described by a modern version of the Phillips-curve which relates deviations of inflation from some expected path to deviations of real output from potential output. New Keyensian models on the foundations of sticky prices have been influential in this modern development of the Philips curve and many of the models used in research and practice are derived from a staggered price setting model (Goodfriend, 2005). Empirical support for the modern versions of the Phillips-curve is weak compared with the IS relationship. Some of the problems include measurement issues, for example the difficulty in measuring real output and inflation in real time and the even more vexing problem of measuring potential output.

The third equation in the standard model is a policy reaction function that relates the policy interest rate to deviations of inflation and output from their respective targets. Though a money demand function can easily be incorporated in the model, it is redundant and in practice typically excluded (Bindseil, 2004). A policy reaction function of this kind expresses the understanding that the appropriate long-term goal for monetary policy is the pursuit of low and stable inflation with the realisation that the long and variable lags of that relationship has output consequences over a shorter horizon that should not be ignored from a welfare perspective and cannot be ignored from a political perspective (Goodhart, 2005: 7-8).

The consensus summarised here is both normative and positive, with the model just described summarising the positive understanding of the economy expressed by the consensus. Normatively the consensus can be summarised in a list of prescriptive statements about what central banks should do, for example the following list from Mishkin (2007):

1. Price stability should be the long-run goal of monetary policy

2. Central Banks should adopt an explicit nominal anchor

3. The Central Banks should be goal dependent and held accountable to the public

4. But the Central Bank should have instrument independence

5. A Central Bank should be transparent, especially through an extensive communication strategy

6. A Central Bank should have the goal of financial stability

It is the last prescription (the focus on financial stability) that is most interesting given recent experience. It stands somewhat apart from the first five though and is only implicitly captured by the consensus on inflation targeting. The connection between the first and last prescriptions is, however, made explicit in the literature on appropriate responses for asset price bubbles, where, for example, Bernanke and Gertler (1999) connected the "sustained damage to the economy" by an asset price collapse with a failure by the central bank to act against deflationary pressures.

But the model of the economy that guides decisions under the modern consensus does not accommodate the focus on financial stability, as is explained in section 4. The problem is not just Tinbergen's rule and the need for additional instruments to pursue targets in additional to price stability, it is that the financial sector (and its fragility or stability) is not accommodated in the consensus model.

Nevertheless, the goal of financial stability is widely recognised (Crockett, 1997; Goodhart, 2005; Svensson, 2009a) and brings particular modelling challenges. The central bank's role in prudential supervision implies an ability to identify risks to financial stability in a forward-looking manner, the ability to assess the risks associated with the current and likely future circumstances of the financial sector, conditional on policy actions such as (i) the stance of monetary policy (ii) the lender-of-last resort facility and (iii) "softer" instruments such as financial stability reports by financial firms (Bårdsen et al., 2006). While all central banks assess these risks, they often do so without the aid of formal models that connect economic developments, policy and financial fragility.

4.1 Models used by prominent central banks

To determine whether Central Bank models provided information relevant to judging the risk of a credit bubble it is necessary to discuss models used at leading Central Banks briefly. Models have a long-established use in monetary policy, both to ensure consistent and coherent policy decisions and to facilitate communication.

A recent survey of models used at leading Central Banks – by Zhu (2006) – shows that they typically use a suite of models that include large-scale simultaneous equation models of an older vintage and more modern Dynamic Stochastic General Equilibrium (DSGE) models. In practice the DSGE models are mostly hybrid models, where the core model is the solution to the inter-temporal optimisation problem of the decision makers in the model either with rational expectations or alternatively with expectations based on market forecasts or forecasts from smaller time series models such as VARs (Zhu, 2006). The European Central Bank, for example, maintains an older large-scale simultaneous equation model while also using a DSGE model. Less typically, the Bank of England stepped away from its older model completely in 2005 and has since been using a new quarterly model with a DSGE core (Muellbauer, 2009).

These models provide an input in the monetary policy process[13] in these central banks and their construction reflects the widespread consensus that emerged in monetary economics over the preceding 20 years. The transmission mechanisms incorporated in these models indicate the channels

[13] As Sims (2002) showed, the policy process at leading central banks uses model results combined with non-model information about the economy, from surveys and other data, as well as subjective judgments.

along which risks to the financial sector might have emerged as they were applied in the years leading up to the financial crisis. Boivin, Kiley and Mishkin (2010) trace the evolution of monetary economic thought by the transmission mechanisms incorporated in major policy-oriented models, including both large-scale simultaneous equation and DSGE models. They distinguished between neoclassical channels (where financial markets are assumed to work without friction, or with frictions in only the price process) and non-neoclassical channels (where there are financial market imperfections). It is a distinction that will also be useful here, as the inability of the monetary policy to anticipate the financial crisis will be closely associated with the relative neglect of the non-neoclassical channels.

The neoclassical channels identified by Boivin et al. (2010) are the well-known channels along which changes to the stance of monetary policy affect investment and consumption expenditure and international trade. It is the effect on monetary policy on the user cost of capital, on the exchange rate, on household wealth and the incentives for intertemporal substitution that are captured by these neoclassical channels.

Policy oriented models used at Central Banks incorporate these channels at their core: Boivin et al. (2010) describe the investment channel as a "standard feature" in large scale econometric models at Central Banks, including the FRB/US model used at the Fed, and in the Tobin's Q version of this channel it is also present in the DSGE models used by Central Banks, such as the EDO model at the Fed, the New Area Wide model at the ECB and the Bank of Canada's ToTEM.

Turning to consumption, wealth effects follow from modern consumption theory and, consequently, are incorporated in the large policy oriented models such as the Fed's FRB/US model, through the magnitude of the effect is small in that model, as in much of the related empirical literature (Catte, et al. 2004). Intertemporal substitution lies at the heart of the dynamic theory around which DSGE model are built, but here too the empirical evidence suggest only modest effects for changes to the stance of monetary policy and consequently this channel has been de-emphasised in the large-scale policy-oriented models.

The last of the neoclassical channels concern international trade, and traces the effect of monetary policy on the exchange rate and then via changes in net exports on aggregate demand. This channel has typically been more important in open (especially small open economies) (Boivin, et al, 2010). A typical example is the core forecasting model of the South African Reserve Bank (SARB), where the policy interest rate determines the prime overdraft rate which affects the equilibrium model for the real effective exchange rate and net exports along that route (Small, Pretorius and Ehlers, 2007).

While frictions are restricted to the price setting process in the neoclassical channels, non-neoclassical channels are those that arise due to a number of other frictions in financial, goods and services markets. One group of non-price setting frictions has traditionally been called the "credit view" of the

transmission mechanism and includes the effect of government credit on the credit market, the effect of bank lending and bank capital and the effect of firm and household balance sheets (Boivin et al. 2010). A second group of nonprice setting frictions that have an effect on transmission mechanisms are those that have been associated with the "new monetarist" economics, especially frictions in the exchange process due to information asymmetries, problems of commitment and spatial separation (Williamson and Wright, 2010).

Common to these otherwise distinct literatures is the central role for financial intermediaries in these non-neoclassical transmission mechanisms. And financial intermediaries played a central role in the financial crisis, in financing the property boom and in facilitating the gearing of those transactions on the capital markets as argued above. It is therefore striking to observe that these channels are largely absent from the modern policy oriented models used by central banks. Neither large-scale macro-econometric models nor DSGE models typically include a bank lending channel or other effects associated with the "credit view" (Boivin at al., 2010).

The gap between the standard model and models with non-neoclassical channels emerges clearly from a recent frank description of the standard model by scholars who have done much to develop that model over the last decade. Fernández-Villaverde, Guerrón-Quintana et al. (2010) use a standard DSGE model that is "used to inform policy in many central banks…[and] that has proven successful at capturing the dynamics of the data" (2010: 5). Their model consists of households and firms, a central bank (with a Taylor rule), and Calvo pricing as a nominal rigidity[14]. Money enters their model in the utility function of households[15] and the only frictions are those of the pricing system. Crucially, the agents are identical since the authors "do not want to have a complicated model with heterogeneous agents that is daunting to compute" (Fernández-Villaverde et al. 2010: 6). But having made these decisions for the sake of consistency with the modern DSGE literature and for tractability, the authors are left with a model that precludes a role for financial intermediaries and the non-neoclassical transmission channels for monetary policy. Policy makers informed by such models would not have been alerted to potentially destabilising financial fragility; the financial sector is, in fact, absent from the model.

4.2 Monetary models with financial fragility

To show that financial fragility cannot emerge from the current crop of core models used by central banks it is necessary to give content to the concept of "financial fragility". This is, however, easier said than done: there are a number of rival definitions of financial fragility.

[14] While they specific a continuum of households their aggregation is trivial due to the assumptions of separable utility and complete contingent markets (Fernández-Villaverde et al. 2010: 6).

[15] That is to say without "sound justification" (Fernández-Villaverde et al., 2010: 5).

One important and intuitively appealing tradition in this literature conceptualises financial fragility in institutional terms, with stability defined in terms of the (i) stability and credibility of key institutions as well as (ii) the stability of key markets, such that prices reflect underlying fundamentals[16] (see, for example Crockett, 1997). In contrast with this emphasis on institutions Mishkin (1994) and others have conceptualised financial instability as a disruption in the flow of information in financial markets, with shocks - or asset price bubbles - preventing the markets from allocating resources efficiently. The focus on information and especially asymmetric information highlights the risks of moral hazard and adverse selection.

These definitions are not however easy to incorporate in a model, especially a model that captures the welfare consequences of financial instability. To that end Goodhart, Sunirand and Tsomocos[17] have suggested a new definition of financial fragility that is explicitly aimed at modelling the welfare effect of financial instability that emerges as an equilibrium outcome in the model. At the heart of their concept of financial instability is the combination of (i) high probability of default for banks and (ii) low profitability for banks. This allows the formulation of a model that is designed to analyse the consequences of risk taking by individual banks, the possible contagious relationship between banks as well as provide a framework for analysing regulatory policy and its effect on financial fragility (Goodhart et al., 2006).

To what extent could the consensus model be expanded to include such a focus on financial fragility[18]? The concept of financial fragility with bank default and profitability at its core requires a role for financial intermediaries in such an expansion of the consensus model. This will present a real difficulty: Most of the core models in the modern DSGE framework use representative agents in the various model sectors. While some of the models specify a range of, say, households, these are typically specified in such a way as to render aggregation trivial (e.g. Fernández-Villaverde et al. 2010). Bank heterogeneity is, however, at the heart of the concept of financial fragility[19], and not just bank

[16] Identifying the key institutions (those where stress and failure will have consequences beyond the an "limited group of customers and counterparties" (Crockett, 1997) is difficult in practice. The recent crisis suggests that well-informed central banks can err in this judgement. Nevertheless, reforms under consideration for the financial regulation internationally emphasise the position of "systemically important institutions".

[17] Important papers in this literature include: Tsomocos (2003a; 2003b) and Goodhart, Sunirand and Tsomocos (2004; 2006).

[18] This discussion draws on Bårdsen (2008: 8-13), but the criteria envisioned for an adequate model here differ notably form his list.

[19] Heterogeneity in the banking sector is critical for a model of financial fragility: in a representative agent model either all banks (the bank) will fail, or not, while the feature of financial fragility that is of interest here is the failure of some banks, while others survive, perhaps in a more fragile condition. Further there is no possibility of an inter-bank market (the source of much contagious interaction between banks and prominent in this regard in the present crisis) without heterogeneous banks (Goodhart et al., 2006).
Some DSGE models have incorporated financial friction by way a financial accelerator, in which a representative agent model with asymmetric information generates balance sheet effects for the firm through one-period stochastic optimal debt-contracts with costly verification. Though this is a successful strategy to include balance sheet effects, it does not create any role for banks in the model, nor is there any room for regulatory policies in a framework where the equilibrium is always constrained efficient (Goodhart et al., 2010: 2).

heterogeneity but the possibilities of trade and default require heterogeneity across other decision makers in the model too.

More than heterogeneity is required though; the financial sector in the model, and money as an asset, has to affect the real outcomes of the model; money must not be redundant as it often is in the consensus model. For money to assume this role though it is necessary to assume incomplete financial markets and liquidity risk. With missing markets the decision makers are unable to hedge against all possibilities, and this introduces a feature common to financial crises, i.e. unanticipated events of low probability but extreme consequences. The missing markets assumption also links with the requirement of a policy model, as the incompleteness of markets creates, at least in principle, scope for welfare-enhancing policy intervention.

A stochastic element could be added to such a model by allowing shocks to the macroeconomic environment that would affect the ability of different decision makers to honour their debt obligations and the terms on which banks are willing to contract with private decision makers, thus creating a credit channel. Goodhart et al. (2004)[20] have shown that a model along these lines can generate heterogeneous default probabilities and these together with fluctuations on bank profitability generate financial fragility as an equilibrium outcome in the model. With default as equilibrium outcome the model would be able to trace contagion effects too, for example by assessing the risk of contagion in the inter-bank market and credit markets.

This kind of heterogeneity, where different kinds of households, intermediaries and firms face different budget constraints, different balance sheets, information sets and information costs show the type of microfoundations required for a monetary policy model that would be suitable to analyse financial fragility as a core concern of policy model[21]. It is not the microfoundations of the DSGE models used in core monetary policy models though[22].

[20] Goodhart et al (e.g. 2006 and 2004) builds on earlier work in this direction by Dubey, Geanakoplos, and Shubik (2000) and Shubik and Wilson (1977).

[21] The RAMSI model under development at the Bank of England (discussed below) is an example of the microeconomic foundations envisioned here.

[22] Hoover (2010) identified three distinct programs to develop microfoundations for macroeconomic models, which he called the (i) the aggregation programme, (ii) the general-equilibrium programme, and (iii) the representative-agent programme. The microfoundations described above are closer to the heterogeneity that Hoover identified in Keynes and the aggregation programme of Klein.
By contrast, the microfoundations used almost universally in modern macroeconomics is of the representative agent kind, on the shortcomings of which see Hoover (2008, 2009 and 2010). The tremendous problems of aggregation and the problems of working with the utility function of a representative agent as if the connection to the utility functions of individuals is not deeply problematic (and perhaps insurmountable) has never been answered (Hoover, 2010). Under these circumstances the widespread adoption of representative agent models has the character of an ideological response (Hoover, 2009).

Two recent examples demonstrate the potential of models that satisfy the criteria mapped out above: Recently, Goodhart, Osorio and Tsomocos (2010) offered a model that satisfies the requirements mapped out above (allowing for default in both mortgage and credit markets) and that has been applied to questions raised by the financial crisis. To demonstrate the potential use of the model they examined a situation where the economy is hit by an initial adverse supply shock, which they relate to rising oil and commodity prices in the US and developed world over the period 2004 to 2008. Monetary authorities responded to this supply shock by raising interest rates to contain the inflationary risk, but this put pressure on house prices in the USA and contributed to the sub-prime mortgage crisis. The model also allows them to trace emergent financial fragility (and the role of monetary policy in creating these pressures) as households defaulted and the profitability of banks declined.

The second example is the Risk Assessment Model for Systemic Institutions (RAMSI) model under development at the Bank of England, which is designed to assess on a bank-by-bank and system-wide basis for the financial sector in the United Kingdom (Aikman et al, 2009). At the model's core is a highly disaggregated and heterogenous financial sector reflecting the balance sheets of the ten largest banks in the UK at the end of 2007. The structure of the model allows for extensive balance sheet interdependence and liability-side feedback in the financial sector. As a demonstration they showed how, in their model, a single bank which defaults for fundamental reasons causes two other banks to fail, the second because of a loss of confidence (that exacerbates existing vulnerabilities) due to perceived similarities with the first failing bank and the third due to counterparty losses and mark-to-market balance sheet deterioration caused by the asset sales of the other two failing banks.

It is the departure from representative agents that is the major break for these models relative to the current vintage of DSGE models. But in other respects the distance to mainstream models is not so large: they are dynamic equilibrium models and though the model can have the structure to generate model consistent expectations, e.g. Goodhart et al. (2004), that need not be imposed, e.g. Aikman et al. (2009). This is not to minimise the importance of the representative agent approach to microfoundations to mainstream models, but as Hoover (2010) has demonstrated, that part of modern macroeconomic method has never rested on firm foundations. Rejecting representative agents is rejecting an ideological stance (Hoover, 2009) rather than a solidly defended part of modern macroeconomic models.

Having said that the immediate prospects of a generalised monetary policy model that include the methodological prescriptions developed above are dim. The existing examples are focussed on narrow questions relating specifically to financial regulation and are not designed to assist in forecasting inflation, or the output gap or many of the tasks performed by the core policy models.

By implication models developed along these lines will not replace the core policy models in use at central banks but will add to the information used in the policy process. This begs the question of how a new model should be added to the suite of models used by monetary authorities, how it will influence the policy process and what will happen when its recommendations conflict with that of other models in the suite?

To put these questions into perspective it is useful to see how central banks use models in the policy process. Sims (2002) reported on interviews with policy committee members at the Fed, the ECB, the Bank of England and the Sveriges Riksbank and for the relevant result was that all of the policy committees included a large set of quantitative (and even non-quantitative) information about the state of the economy in the policy discussion *in addition* to the outcomes of formal econometric models[23].

The use of non-model information is clearly demonstrated by the observation that at two of the leading inflation targeting central banks, in the UK and Sweden, econometric models do not determine the shape the fan chart that shows a "probability density function" around the conditional inflation forecast. (Sims, 2002: 27). Or as the Bank of England's Inflation Report explained their method:

> The MPC's view of the likely outcome for inflation in any future quarter can be represented by a probability density function… The Committee uses the experience of past forecast errors to inform its judgment. But the MPC does not mechanically extrapolate those errors in order to calibrate its uncertainty for each forecast. Rather it makes a subjective assessment, based on the economic conditions prevailing at the time (Bank of England, 2002: 48).

Though it is doubtless important, the question of whether subjective methods currently used by policy committees to aggregate the information from models and elsewhere is optimal from a decision-theoretic perspective is not central to this paper. The point is that they combine the information from a suite of models *and*, to the dismay of Sims (2002), that combination is not a formal Bayesian procedure. John Vickers – a former member of the Bank of England's MPC described this subjective procedure as follows:

> Models got two cheers. The pluralist approach to modelling gets three. That is why the Bank, like many other organisations, has a suite of models, rather than being wedded to a single model... Thus there is no such thing as the Bank model. Even the core model plus the latest

[23] There are many reasons for this, including the belief by policy committee members that the additional information give them a more accurate picture of the current state of the economy and hence a superior basis for their short term forecasts of key variables, in Sims's words "several of those involved in subjective forecasting, at more than one central bank, expressed the view that the advantage of subjective forecasts is almost entirely in getting the current and the next quarter right" (Sims, 2006: 21). The desire to respond to large and unusual events is another reason for the persistent use of the non-model information. A third reason is the belief that no single model captures the range of issues relevant to an MPC (Vickers, 1999).

> data are nowhere near sufficient to determine the forecast, since a great deal of judgment, much of it informed by other modelling, goes into the making of a forecast (Vickers, 1999: 11).

The argument in this section therefore built a case for one more model to be added to the suite already used at leading central banks. Amongst the methodological prescriptions for this model, the major departure from the current consensus model is the need to abandon representative agent models and the include diverse and economically relevant financial sector.

5. Conclusion

I have told a missing model story: the suite of models that guides policy decisions at prominent central banks were not designed to warn against financial fragility of the kind that led to the financial crisis in 2007-2008. When, under the pressure of events following the 2001 recession and fearing deflation, central banks maintained an accommodating stance for monetary policy there was nothing in their suite of models to highlight the associated financial fragility risks. In that respect John Muellbauer is right. But the implications drawn here are less dramatic than his: while the representative agent approach to microfoundations now seems indefensible, other aspects of modern macroeconomics are not similarly suspect. The case made here is rather for expanding the suite of models used in the regular deliberations of monetary authorities, with new models that give explicit roles to the financial sector, to money and to the process of exchange. Recommending a suite of models for policy making entails no methodological innovation. That is what central banks do; though, of course, how they do it is open to improvement. The methodological innovation is the inclusion of a model that would be sensitive to financial fragility, a sensitivity that was absent in the run-up to the current financial crisis.

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