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Financial frictions and macroeconomic models: a tour d’horizon

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The benchmark sticky-price microfounded model yielded a number of insights for monetary policy-makers but failed to consider the implications arising from easy money and expanding credit and balance sheets. The promising search for a microfounded workhorse model of financial frictions is still in its early stages. And the ongoing global financial crisis poses a number of questions about both the fundamental causes of business cycle fluctuations and the extent to which monetary–fiscal and debt management policies should be jointly determined. I assess recent developments and provide some pointers for the micro-founded agenda.

Keywords: DSGE models, financial frictions, monetary and fiscal policy

JEL codes: E43, E44, E47, E58

1 INTRODUCTION

The Basque language is the despair of scholars and the most mysterious of all known languages.

Aldous Huxley

The foundations of knowledge, which include language and economics, can be subject to intellectual earthquakes.¹ Such earthquakes test the robustness of established views and may lead to previously unanticipated directions for thought. The classic example is the impact of the Great Depression on the direction of economics, as it led to the development of an obligation for the government to run counter-cyclical economic policies and subsequently to the growth of national income accounting, which laid the basis for the development of macroeconomic modelling.²

* I am grateful for helpful conversations with and comments from Philip Arestis, Mike Joyce, Jack Meaning, James Warren and participants at the BIS-OECD Workshop Panel on Policy Interaction: Fiscal Policy, Monetary Policy and Debt Interaction, the Reserve Bank of India and 10th Conference on Developments in Economic Theory and Policy in Bilbao. I am also grateful to an anonymous referee for help in clarifying my thoughts in this survey of my recent work. Any remaining errors are my own.

1. I sometimes wonder whether Isaiah Berlin’s (1978) separation of thought into the *Hedgehog and the Fox* is a suitable classification to think about micro-founded macroeconomics versus the more subtle form of political economy that many seem to wish we used instead. I would like to think that such models provide a suitable single lens from which to start.

2. See, for example, Ayres (1946).

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The subsequent development of macroeconomic stabilisation policy seemed to have been a huge success during the so-called post-war 'Golden Age', but cracks in the foundations ultimately undid the practice. The near loss of monetary control in the 1970s awakened an interest in macroeconomic theory for deriving aggregate behavioural equations from optimisation problems in which agents solved for intertemporal and intratemporal decision rules subject to an economy-wide resource or budget constraint. The hope was that such models would be usable for policy analysis in terms of welfare because the fundamental relationships were stable in the face of changes in policy. Traditional economic models, which are heavily reliant on econometric estimation, were thought to fall foul of the Lucas Critique. As per some heterodox and agent-based approaches, such models attached more importance to external realism than to internal coherence. By contrast, the macroeconomic models with microfoundations that became popular in the 1990s attached more importance to internal (logical) coherence than to external realism *per se*. What I will try to show in this paper is that this latter approach allows the development of models that retain internal coherence and allow a better characterisation of the economic environment and hence can still be used for policy analysis.

The current global financial crisis turned out to be another such earthquake and one positive result has been an explosion of work by macroeconomic modellers striving to develop micro-founded models with financial frictions. Such frictions would lead to time-varying endogenous wedges between different sets of interest rates and in which supply effects may impact on various interest rates and change aggregate demand and potential output levels.³ Many have argued that micro-foundations had always been built on a fault zone and thus were simply not likely to survive much of a shock. In this paper I will try to show how micro-founded models can be extended to encompass real problems such as financial frictions, without necessarily sacrificing internal coherence; and I will also consider the implications for monetary policy. I shall argue tentatively that there is considerable scope for optimism over the micro-founded agenda and that some form of financial workhorse will emerge.⁴

The long expansion in activity from the early 1990s to late 2008 was a period in which finance became both content and proud, perhaps through benign neglect.⁵ Financial engineering and innovation created new bridges from savers to borrowers and it seemed to many that credit markets were being well oiled by the financial sector.⁶ In parallel, in the workhorse models of this period, the typical rigidities were simply those of sticky prices and monopolistic competition, which generated deviations from the flex-price equilibrium of the economy in response to exogenous shocks. Accordingly, the output gap and the inflation rate became a sufficient pair of statistics to monitor the economy.⁷

3. See Chadha/Holly (2011) for a treatment of a number of partial equilibrium and general equilibrium modelling approaches that try to understand non-conventional monetary policies. Although there is a growing literature, a workhorse model has not yet been developed.

4. The agenda involves writing down general equilibrium models built from the principles of household optimisation that match key stylised facts of business cycle behaviour. The model can then be solved under various forms of stabilisation policies under which the welfare of the household can be assessed and in which the Lucas critique is respected.

5. In 1925, prior to making the decision to return to an overvalued gold standard, Churchill had called for industry to be more content and finance less proud. By 2007, finance, it seemed to many, had it all.

6. With the development of many new credit instruments and the increasing levels of leverage of financial institutions, it seemed that markets were being completed.

7. Ironically, at the same time, many of the price rigidities were being nicely ironed out by an explosion in production from China.

In a forward-looking model, agents simply had to know enough to understand that the monetary authorities would act on the real rate to close any expected output gap in expectation and thus any deviation from the stated inflation target. This real interest rate was controlled by the central bank and was all that was required in order to achieve stability. This model, to my eyes at least, now looks hopelessly inadequate.⁸

Let us compare the prescriptions of the workhorse model outlined in the previous paragraph to the policy initiatives developed in the crisis. Monetary policy became constrained at the zero lower bound (ZLB), in the UK's case since 2008, and this had led to the rediscovery of the importance of open market operations, or balance sheet policies, as a way of influencing interest rates beyond the normal policy horizon. It was well known that fiscal policy operated to help aggregate demand in a recession; but here it was called up also to recapitalise banks. This extra function as a fiscal 'backstop' meant that any concern about borrowing limits would not only frustrate countercyclical policy because escalating market-determined interest rates would bear down on activity but would potentially leave the financial sector highly vulnerable to further shocks. Furthermore, the fragility of the role of commercial banks as maturity transformers was revealed and the systemic lack of liquidity in the event of risk aversion exposed. Balance sheet operations expand the size and composition of the central bank balance sheet, reduce the duration of financial markets' bond holdings and increase liquidity. These operations involve the issuance of short-term debt–fiscal instruments (interest-rate-bearing reserves or T-Bills). So, as well as helping to reduce long-term rates by signalling lower rates or by offsetting risk premia, these monetary–fiscal operations hedge liquidity risk. In some sense, we stumbled towards these solutions and need to develop models to help us understand the extent to which they should remain part of the policymaker's toolkit.

In the next section we present a brief overview of the simple rules debate and how financial premia impact on the economy. Section 3 then discusses the external finance premia and its introduction into macro models. Sections 4 and 5 briefly introduce several different approaches to financial frictions. And Section 6 outlines a model that introduces heterogeneity and assesses the implication for policy. The final section concludes with some thoughts on financial frictions.

2 THE CHALLENGE

Let us remind ourselves about the policy prescriptions that emerged from the sticky price version of a DSGE model and then turn to the basic insight offered by the existence of a financial wedge and provide some intuition on the likely consequences for policymaking.

2.1 Simple monetary policy

In the simple linearised New Keynesian model (see Figure 1), the policy reaction function simply has to react by more than any given change in inflation so that the real interest rate acts to bear down on any output gap and drive inflation back to its target. At point A, the policy rate hits the zero lower bound and if inflation continues to fall, real interest rates will rise. This linear model is subject to a number of well-known control problems: (i) changes in the natural rate (the intercept), which cannot be easily measured, will lead to monetary impulses from nominal rates that imply the incorrect real rate of interest;

8. In Chadha et al. (2013b), we show how money and financial factors were excluded by design from having any amplification impact in the standard model.

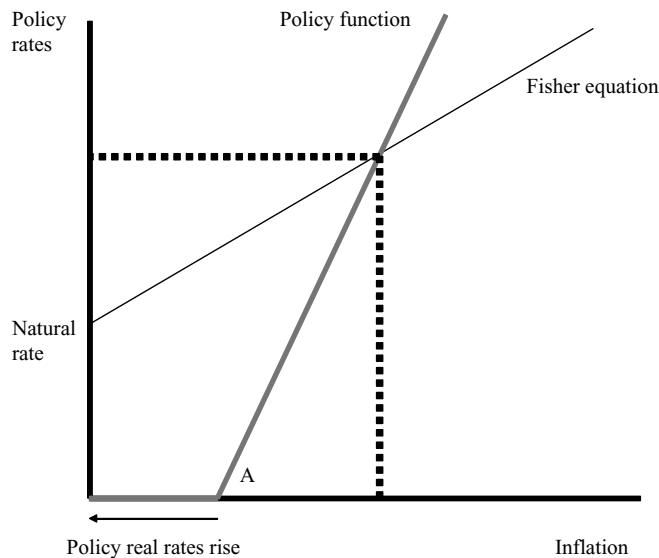


Figure 1 The simple NK framework

(ii) measuring the output gap and then forecasting the change in inflation that is implied is very difficult in real time; (iii) with no set of asset prices in the model, we are left hoping that the use of a single policy rate leads to clearing in credit markets that does not leave the economy in a fragile state; and finally (iv) if rates were to fall to zero and deflationary pressures continued to escalate, real rates would rise and the economy would be in serious danger of not being able to be stabilised.

The need for micro-foundations for financial frictions is thus motivated by each of these objections. The natural rate can be interpreted as reflecting monetary and financial conditions elsewhere, so that, for example, if the financial sector is expanding at a fast rate, the natural rate rises. The operation of the financial sector may impact on both measured potential supply and current demand and thus make any kind of output gap calculation almost impossible. Money market clearing in a host of short-term and long-term financial markets will determine the set of interest rates that are relevant for consumption and investment decisions and these may not be strictly proportional to the short-run policy rate at all times: in the language of finance, they may be disconnected. Finally, if the policy rate hits the lower zero bound, we may need to think about operating on other asset and bond prices in order to gain some traction on the monetary transmission mechanism.

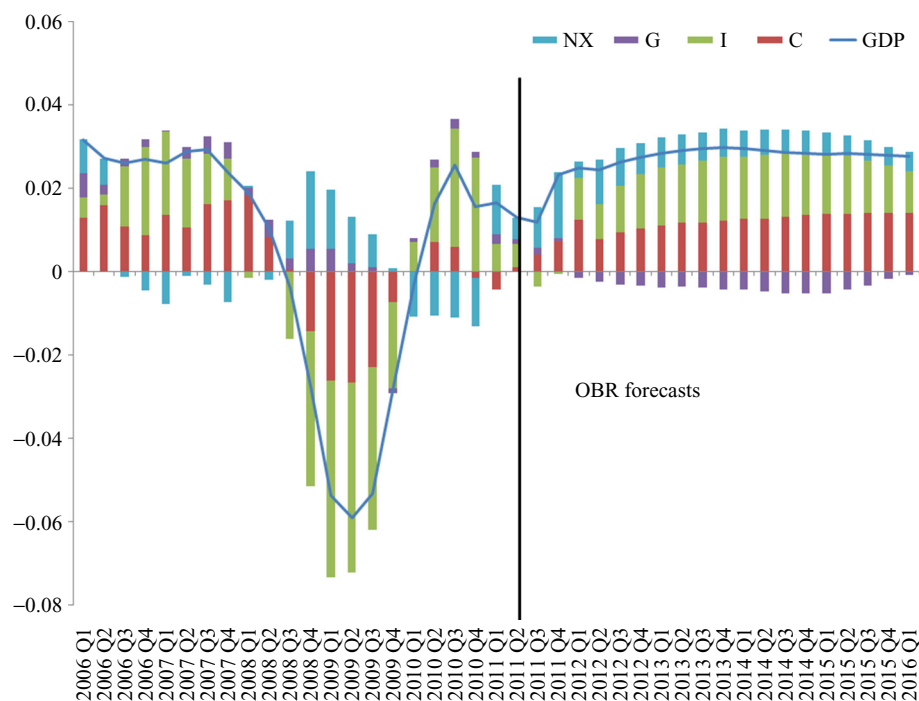
2.2 Financial wedges

There is no workhorse model (yet) for understanding financial frictions. But Hall (2009) provides a useful taxonomy. He reminds us that an increase in any financial friction will tend to increase the interest rate wedge between those who provide capital and the cost of capital paid by firms and such a wedge will tend to depress output and employment. The story is similar to the Diamond–Mirrlees analysis of the inefficiency of taxation of intermediate product, with capital playing the role of an intermediate product. The legs of the argument are that an increase in financial frictions acts to increase the price of capital and so reduce its demand and because of the economy-wide resource constraint

this will increase both the output–capital ratio and the consumption–capital ratio accordingly. Through the Cobb–Douglas production function, the labour–capital ratio rises with output–capital. And the lower level of capital induces a fall in output. The argument goes through in the opposite direction with a fall in the size of financial frictions. Indeed, under this kind of analysis, financial frictions are embedded in the supply side of the economy and may be particularly hard to understand in a New Keynesian (NK) Model, which concentrates on demand and cost-push shocks in the production of goods.

2.3 The recent UK recession

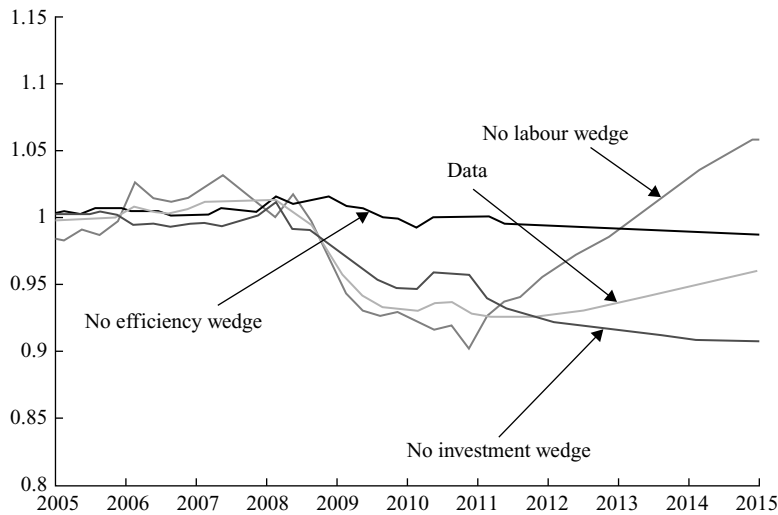
The kind of analysis outlined in the previous section tends to lead to the conclusion that in response to changes in financial frictions, consumption and investment ought to move in opposite directions, as the economy switches from capital to labour. But what we consistently find in many economies is that consumption and output move together quite markedly, especially in the recent recession, which most commentators would imagine was closely related to revelation of large-scale financial friction (see Figure 2). This means that we need to find micro-foundations for frictions that drive consumption and investment in the same direction over the business cycle. In fact, the problem is even worse. In Chadha/Warren (2012), we took a standard real business cycle (RBC) and a model in which an external financial premium was driven negatively by asset prices



Notes: NX: net exports; G: government; I: investment; C: consumption. To the right of the vertical line is the forecast period.

Source: Chadha/Warren (2012).

Figure 2 Demand-side decomposition of UK output



Source: Chadha/Warren (2012).

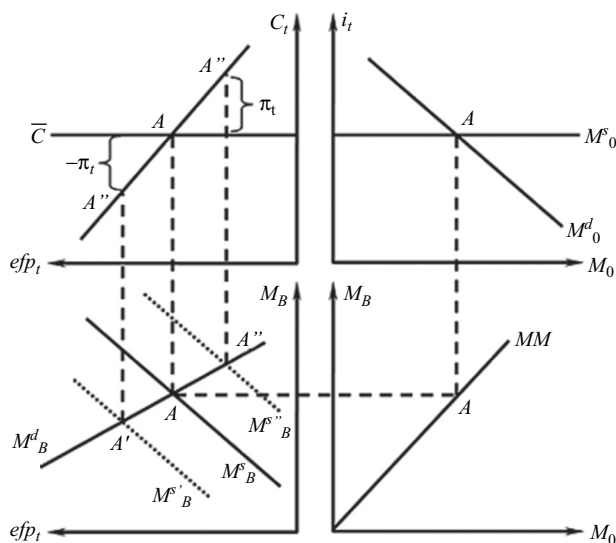
Figure 3 Accounting for growth with and without efficiency wedges

(Bernanke et al. 1999) and allowed the relative magnitude of asset prices in the second model to increase markedly, relative to productivity and various demand shocks. First we took data from the RBC model and examined the evolution of output during the UK recession without one of each of three possible wedges in turn, or shocks: investment (aka financial), labour, or efficiency (or productivity). When we accounted for the causes of the business cycle in the data produced by this model, in the fashion of Chari et al. (2007), we found that it was when we removed the efficiency/productivity wedge that the model performed the worst (Figure 3).

Then we looked at the second model, when it was driven by asset prices and through the same lens, and it did not look like there was an important story about an investment wedge. In other words, the shock driving the external finance premium looks like a productivity, efficiency or labour wedge, rather than an investment wedge alone, because it drives consumption and investment in the same direction. This finding means that financial frictions may tend look like a supply shock in a macro-model. As far as the early part of the twenty-first century was concerned, therefore, the apparent fall in financial frictions would have been observationally equivalent to an increase in productivity and would simply have led to the central bank stoking up more demand to meet its inflation target. The problem was, of course, that the financial frictions were about to return with a vengeance.

3 THE EXTERNAL FINANCE PREMIA

To help illustrate the implications of financial frictions for demand, Figure 4 traces the impact of the external finance premia (EFP) on activity, as measured by consumption. In this representation, the central bank, in the top right-hand quadrant, sets the policy rate and supplies central bank money on demand in response to any shifts in money demand. The banking system chooses the quantity of broad money that it wants to create from the MM curve, which can be thought of as an optimising decision. The demand for broad money falls in the EFP and the supply increases to set a level of demand at *A*, which is consistent



Source: Chadha et al. (2010).

Figure 4 Money, EFP and demand

with a given level of broad and narrow money, as well as the prevailing policy rate. Shifts in the supply of broad money will thus change the external finance premium and the level of output to A' or A . Thus broad money and the level of activity can be quite distinct from the policy rate or the quantity of central bank money. And, if the lending function relates to some measure of the financial friction, we might be moving closer to a story in which expenditure components that rely on bank lending may co-vary over the business cycle. What we would like to have, in terms of microeconomic foundations, is a consumption path that is not only tilted by the policy rate but also affected by the quantity of credit offered.

3.1 Open market operations and money

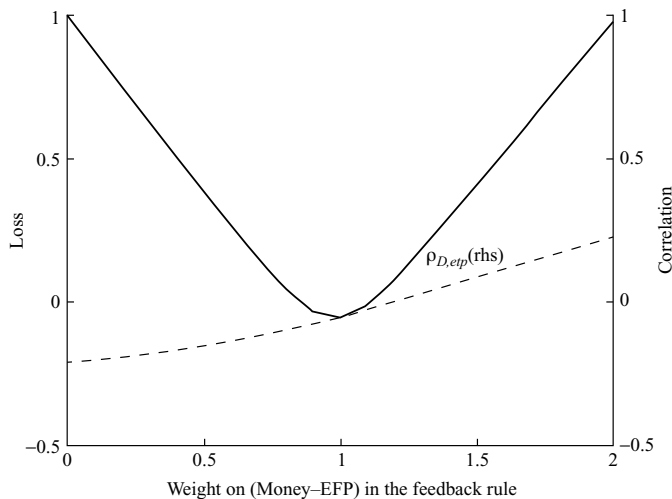
If the policy rate is fixed or bounded at the lower zero bound, policymakers may wish to introduce forms of open market operations to influence market interest rates further along the maturity spectrum.⁹ And so, generally speaking, new initiatives such as quantitative easing are really just an extended open market operation involving the unsterilised swap of central bank money for privately held assets. The key difference is that the duration of the swap is both intended to be long-term and of uncertain length. An open market operation, if unsterilised, leads to an increase in the quantity of base or outside money. This money represents claims on the public sector and will not be neutral with respect to any given expenditure plans if there is a real balance effect that induces a fall in interest rates. This is because the increase in money changes the price of claims on the public sector. If, however, the private sector fully discounts the present value of taxes that will need to be paid to meet these obligations, then these bonds will not represent net wealth and the operation will be neutral. The debate on the efficacy of such operations hinges on the question of whether the supply of outside money changes the wealth position of the private sector (see Gale 1982).

9. The discussion in this section follows closely that of Breedon et al. (2012).

But the analysis of such operations lies outside the remit of the workhorse NK model in which the evolution of monetary aggregates, which are simply a veil behind which real planned transactions were effected, provided no additional feedback to the state of the economy. These models, as already explained, are highly tractable and were used to develop simple, precise policy prescriptions, even at the lower zero bound of the Bank rate, by influencing expectations of the duration of any given level of Bank rate in order to induce exchange rate depreciations or positive inflation shocks and so close any given sequence of output gaps in expectation. In these models, open market operations were neutral because at the lower zero bound money and bonds become perfect substitutes and any swap of one for the other did not change the wealth position of the private sector. In fact, in these models QE-type policies are simply forms of commitment strategies that provide signals about the long term intentions of the central bank to hit a given inflation target.

The NK argument that monetary policy can only work through the management of expectations is not a universal result as it relies on particular assumptions. In these models, financial markets are complete in which a representative agent can spring into life and financial wealth is allocated over an infinite life. Idiosyncratic risk in these economies can be hedged and asset prices depend on state-contingent payoffs. In these cases, the prices of financial assets are not influenced by changes in their net supply, as demand is perfectly elastic. It seems quite possible, though, that demand curves for assets, particularly when issued in large quantities, may become downward sloping; in which case changes in net supply can affect their relative prices. This possibility then means that the relative supply of money or credit can influence market interest rates and so impact directly on expenditure paths without having to rely on pure signalling effects.

In Chadha et al. 2013b, we have explored the advantages to the representative household from using money as an indicator, particularly when it co-varies negatively with external finance premia (EFP). This is because, when the money supply process is dominated by supply shocks, the EFP and money supply tend to move in opposite directions. And this will tend to set up output and inflation variances that may be missed by a simple feedback rule related to inflation alone. Figure 5 shows an illustrative calculation in a model of money



Source: Chadha et al. (2013b).

Figure 5 Information content of money

supply via a loans production function, in which the economy is better stabilised when the correlation between money and interest rates is driven to zero (that is, when the information content from money supply is exploited by the policymaker). As a by-product, we can understand now why money may not have much information for activity in an economy when the central bank has acted to stabilise activity well. We need then to turn to consider how money, inside or outside the private sector, can be created and for what reason it is held.

4 FINANCIAL FRICTIONS IN DSGE MODELS

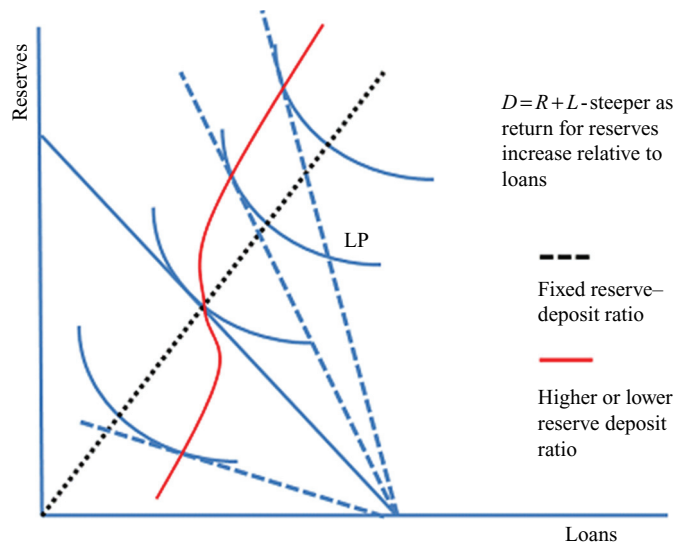
In this section, we examine how three recently developed dynamic stochastic general equilibrium (DSGE) models differ from the ‘plain vanilla’ New Keynesian model by having more than one interest rate. Each model has a New Keynesian core with forward-looking households and firms, optimising consumption and profits, subject to sticky prices and central bank operations conducted with an active interest rate rule. But in each model, one or more interest rates also impact on aggregate demand and have some traction on stabilising the economy. I shall keep my exposition of the micro-foundation devices to a minimum and encourage reading of the original papers for further details. The creation of models with more than one interest rate means that the short-term interest rate performs as an approximate control device at all times and an especially problematic one when the zero lower bound acts to constrain the interest rate path.

In the first model, a variant of Goodfriend/McCallum (2007) developed by Chadha/Corrado (2012), consumers are deposit-constrained and banks choose a mix of lending and reserves holding to meet a given level of deposit demand. Banks produce loans using a combination of the value of collateral and monitoring workers, and also have a preference for liquid reserves. Reserves act as a cushion against hiring and firing of monitoring workers and thus can attenuate movements in the external finance premium, which is given by the marginal costs of loans supply. Figure 6 shows the changes in the optimal reserve ratio as the return to reserves varies with the interest rate premia.

In the second model, developed by Harrison (2011), the consumption Euler equation is tilted by a linear combination of short- (policy) and long-term interest rates. The long-term interest rate deviates from the long-term expectation of the policy rate by a preference term that increases in the relative supply of long to short bonds. The policymaker can offset this premium by buying long-term bonds and reducing the relative supply. And so, when policy rates can fall no more, the purchase of long-term bonds will reduce the average economy-wide interest rate and help stabilise output.

The third model, a variant of that developed by Gertler/Karadi (2011), endogenises the commercial bank (financial intermediary) decision on the appropriate level of leverage to match a given loans-production objective. The commercial bank choice on leverage impacts directly on the external risk premium paid by firms for lending. A negative shock to aggregate demand can lead to a large increase in the external finance premium and a contraction of leverage, so there is a considerable amplification of the initial shock unless the government steps in to provide a bank capital subsidy to allow the premium shock to be attenuated.

For each model we run a similar exercise and assess two key aspects of monetary policy. In each case, we generate a large negative shock to aggregate demand in the model. This acts to propel the economy into a deep recession. We then explore the stabilising properties of a QE-like policy by examining whether output can still return to its steady state, even in the absence of an interest rate response. Then we allow policy rates to fall and examine whether the new instrument complements the policy rate over a business



Note: LP: liquidity preference.

Source: Chadha/Corrado (2012).

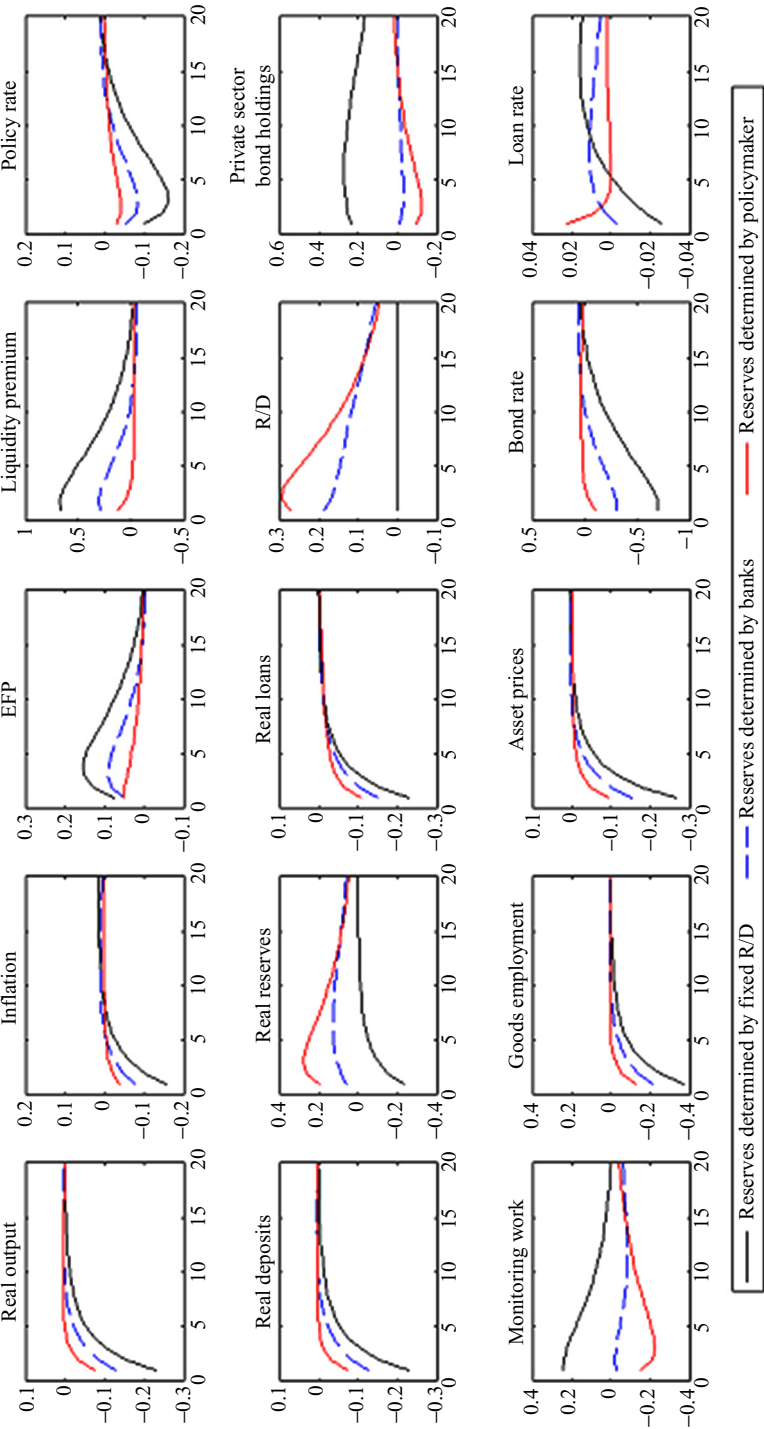
Figure 6 Commercial bank's demand for reserves

cycle. For each model, we assess the extent to which the new instrument of monetary policy is able to generate stability in isolation and compare the results to a preferable stabilising path when used in conjunction with the active policy instrument.

4.1 Banking and monetary–fiscal co-operation

The Chadha–Corrado model (2012) is an extension of the Goodfriend–McCallum model (2007), in which credit-constrained consumers require loans from a commercial bank in order to effect their planned consumption paths. The bank employs a loans-production technology with arguments in the value of collateral and the employment of workers who monitor loans and also has to respect a liquidity constraint in deciding on the optimal levels of the reserve–deposit ratio. The commercial bank's liabilities can thus be funded by a mix of interest-rate-paying reserves and external-finance-premium-paying loans. Chadha/Corrado (2012) find that, in this framework, banks can use reserves as a buffer against costly changes in monitoring costs and so can choose to alleviate some of the counter-cyclical variation in the external finance premium. So we examine the implications from increasing the reserve ratio by some 7 per cent in this model.

The fall in output following a negative demand shock is, in this case, shown to be some 15 per cent (Figure 7). Inflation falls by around 6 per cent, with real wages and employment both falling by something more than 20 per cent, and in this case the increase in monitoring effort by commercial banks puts upward pressure on the external finance premium. The increased issuance of bonds by the government, which tries to stabilise output, also pushes up liquidity premia on bonds. In the two cases where the reserve–deposit ratio is not fixed but is chosen endogenously by commercial banks, the contractionary shock leads to an increase in demand for reserves, which are supplied perfectly elastically by



Source: Chadha et al. (2012).

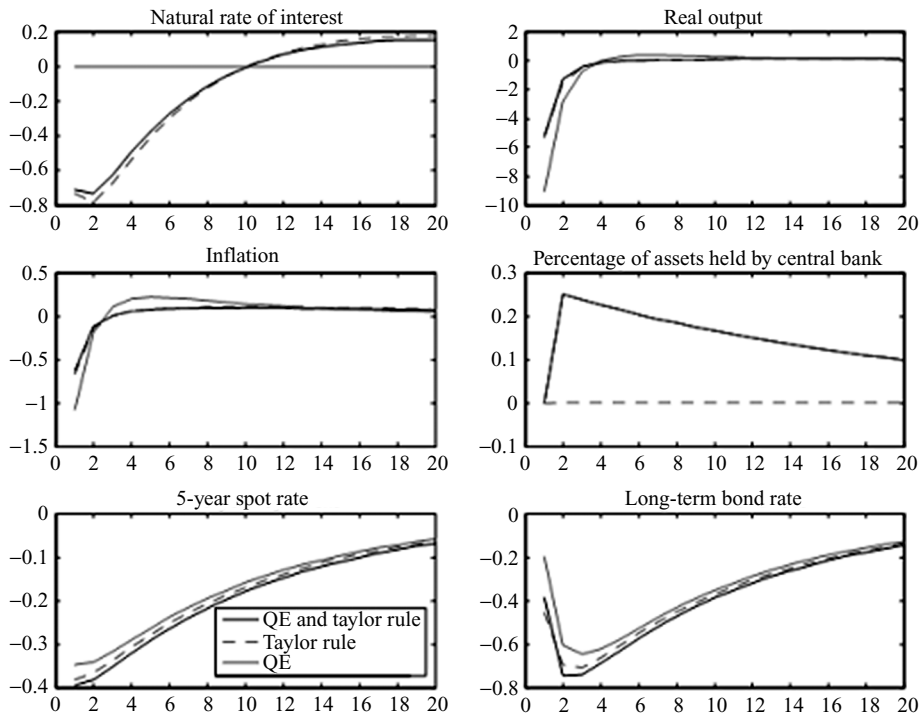
Figure 7 Negative output shock in a bank liquidity model

the central bank. This increase in reserves acts to limit the increase in the cost of loans supply, because banks hold reserves *ex ante* against potential problems with loans. Liquid reserves offset some of the upward shock to interest rate spreads and can mitigate around 30–40 per cent of the shock in this model. In fact, if the non-standard monetary policy increases the reserves–deposit ratio by around 12 per cent, it seems possible to stabilise the economy even if interest rates do not fall at all.

4.2 Portfolio balance model

In Harrison (2011), the representative agent lives in a standard optimising economy with price stickiness, a New Keynesian Phillips curve and a forward-looking spending equation, albeit one in which there are interest rates of both short- and long-run maturity that tilt expenditures. The long-term rate differs from the expected stream of short-term rates because of a preference for short-term bonds, which drives the liquidity premium on long-term bonds up. This implies that even at the zero lower bound the monetary policy-maker has some ability to tilt expenditures by buying long-term bonds and therefore reducing the liquidity premium. And so we consider the impact on long-term bond rates, and hence on consumption, from a monetary authority purchase of some 25 per cent of outstanding government bonds.

We simulate the model with a 10 per cent downward shock to real output, which replicates the experience of the UK. We then show, in Figure 8, three impulse responses to key



Source: Caglar et al. (2011).

Figure 8 Negative output shock in a bank capital model

state variables in the portfolio balance model when the monetary policymaker (i) uses a Taylor rule only, (ii) uses a Taylor rule in conjunction with asset purchases, and (iii) uses asset purchases only to stabilise the economy.¹⁰ In what might be considered normal times, when the zero lower bound does not constrain, policy rates fall by around 75 basis points (bp), and output is stabilised in a year or so. When we also allow for asset purchases, these appear to take some of the workload off the nominal interest rate in correcting for the AD shock, as the policy rate then falls by a little less and allows us to return to equilibrium output at roughly the same time. This suggests a possible but limited role for asset purchases if interest rates become constrained in their movements or if central bankers want to limit the volatility of the policy rate over the business cycle. Asset purchases combined with standard interest rate policy cause the long rate and 5-year forward to fall by a little more than would have been the case without QE-style purchases. But, clearly, asset purchases can bring about a similar fall in long-term interest rates as that implied by a fall in the short rate alone. A long-term interest rate fall of some 100bp would seemingly require a much larger purchase of assets than the 25 per cent suggested here, perhaps more in the region of 50–75 per cent. But in any case such purchases would not offset the fall in output as much as a reduction in policy rates because output responds to both the short- and long-term rate.

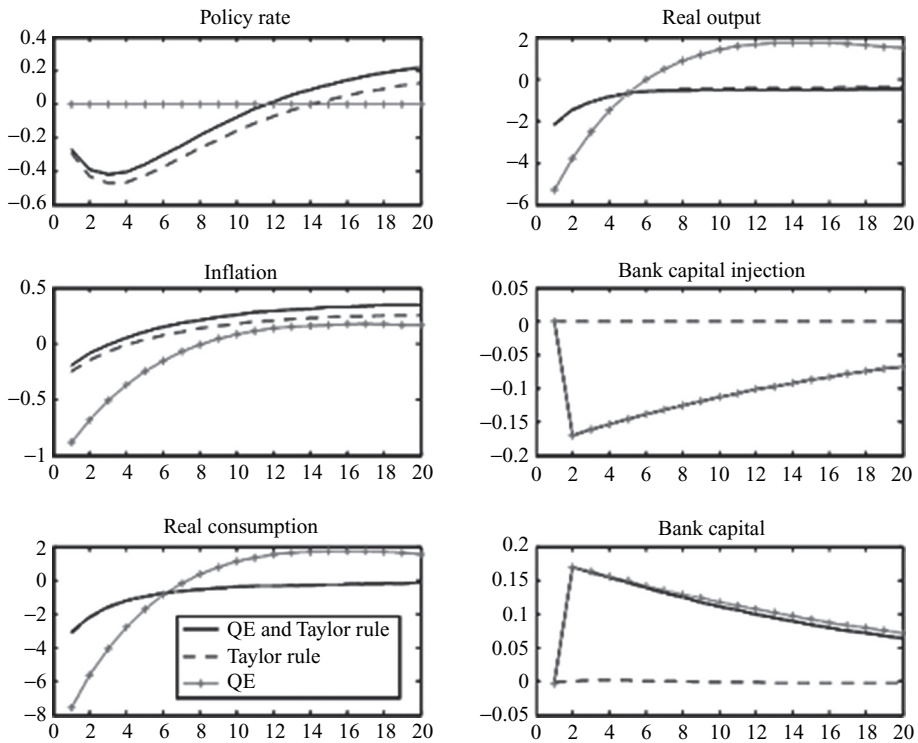
4.3 Bank capital model

The Gertler–Karadi (2011) model is a model of unconventional monetary policy with capital and financial intermediation. The flow of funds from savers to borrowers are organised by financial intermediaries. The liability side comprises deposits from households and bank capital, which are matched with loans to firms to finance their investment. The net return from lending minus monitoring costs must always be greater than the cost of funding deposits at the nominal interest rate. There is therefore an equilibrium level of leverage which reduces in monitoring costs and increases in the interest rate spread between lending and deposit rates. Policy rates will act to reduce leverage by reducing the spread and non-conventional policies can directly impact on bank capital by offering state contingent subsidies or levies to affect the quantity of loans offered by banks, which are always the product of leverage and bank capital employed.

With a model of bank capital, the initial downward shock to output of around 2–3 per cent is stabilised with a cut in policy rates of some 50bp and a return to base in about 4 years, and in this scenario inflation falls to around 0.4–0.5 per cent below target (Figure 9). If there is no ability to cut interest rates and an injection of bank capital of some 17 per cent is employed as the stabilisation device,¹¹ then output falls by around 2–3 times further and there is a similarly larger downward shock to inflation. And whilst that can lead to some stabilisation in output, if interest rates do not rise once the economy emerges from recession, in around 4 quarters on this calibration, it seems that there is a significant possibility of an overshoot in both inflation and output. The bank capital

10. There is no investment or government spending in the baseline version of this model. An interesting extension would be to consider the impact of liquidity premium on the structure of the maturity of private and public sector debt, in which we might expect relative over-issuance of short-term compared to long-term debt to reflect the different costs.

11. Representing the £50bn direct injection calculated by the Bank of England's Financial Stability Report (June 2010) as a percentage of the £300bn of sterling capital and other internal funds held by UK banks as of 1 January 2007 (source: Bank of England).



Source: Caglar et al. (2011).

Figure 9 Negative output shock in a portfolio balance model

model thus suggests that a larger injection of capital than 17 per cent may be required to offset a large negative demand shock and also highlights the need to raise rates once the momentum for recovery is established.

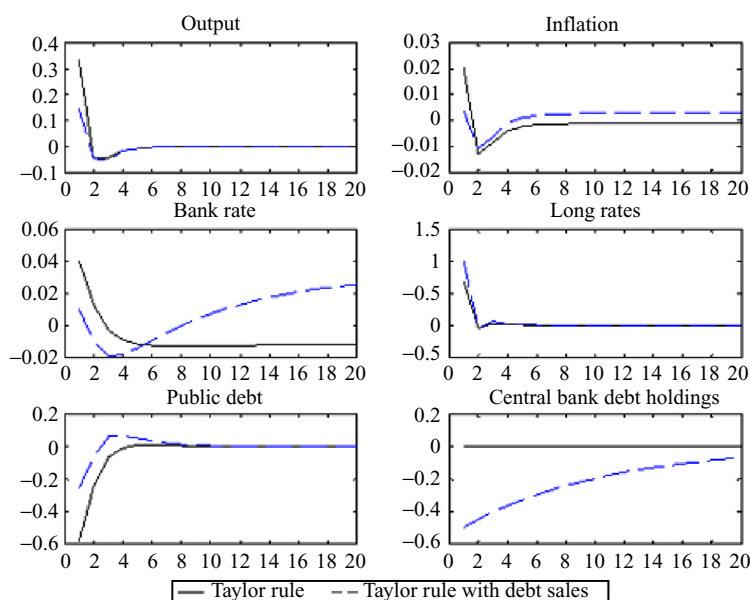
5 A MODEL OF QE AND DEBT SALES

Furthermore, we can investigate the impact of bond purchases within the context of a calibrated general equilibrium model in which fiscal policy, debt accumulation and government or central bank purchases of debt impact on the path of output. The model used here allows for wealth effects from public debt issuance because overlapping agents are finitely lived and may not bear the funding consequences of any given path of fiscal deficits. As well as a standard interest rate rule, we use a deficit rule that feeds back from the output gap. This deficit rule, along with the sequence of interest rates, drives the debt level over time. Here, the representative agent lives in a standard optimising economy with price stickiness, a New Keynesian Phillips curve and a forward-looking spending equation, albeit one in which there are interest rates of both short- and long-run maturity that tilt expenditure. The long-term rate differs from the expected stream of short-term rates because of a preference for short-term bonds, which drives up the liquidity premium

on long-term bonds. This implies that even at the zero lower bound (ZLB), the monetary policymaker has some ability to tilt expenditure by buying long-term bonds and therefore reduce the liquidity premium.

We consider the impact on long-term bond rates, and hence on demand, from a monetary authority's eventual sale of outstanding government bonds. A key parameter in this model is the impact on yield from a 1 per cent purchase of the outstanding debt stock, which reduces net supply as well as shortening the maturity of debt. Given the empirical results presented in Chadha et al. (2013c), we use a conservative estimate of 0.1, which implies that 1 per cent purchase reduces long-term yields by 10 basis points. By embedding a fiscal response in this model, we can assess some of the trade-offs faced by the central bank and the fiscal authority.

We consider the implications for exit strategy by considering what happens when QE is reversed in an expansion. In Figure 10, we run an example shock of a 25 per cent purchase or sale of the initial debt stock by the central bank, which is run down to zero after 10 years. The charts are drawn for the first 5 years following each shock. It is clear from these simulations that the outcome of stabilisation policies cannot be understood without specifying the fiscal policy response to a shock, and hence the extent to which debt accumulation impacts on long-term, and hence average, interest rates. At the ZLB it would appear that the impact of fiscal policy on output is amplified considerably when accompanied by debt sales. And the combination of a ZLB and QE seems to mimic quite well the implied response of policy rates, if they could be lowered below zero, providing we accept that the withdrawal of debt via central bank purchases does have a direct portfolio effect. That said, it is also clear that the use of debt purchases, as a strategy to counteract the ZLB and extreme outcomes, stores up some problems for the future when debt sales may act as a drag on



Source: Caglar et al. (2011).

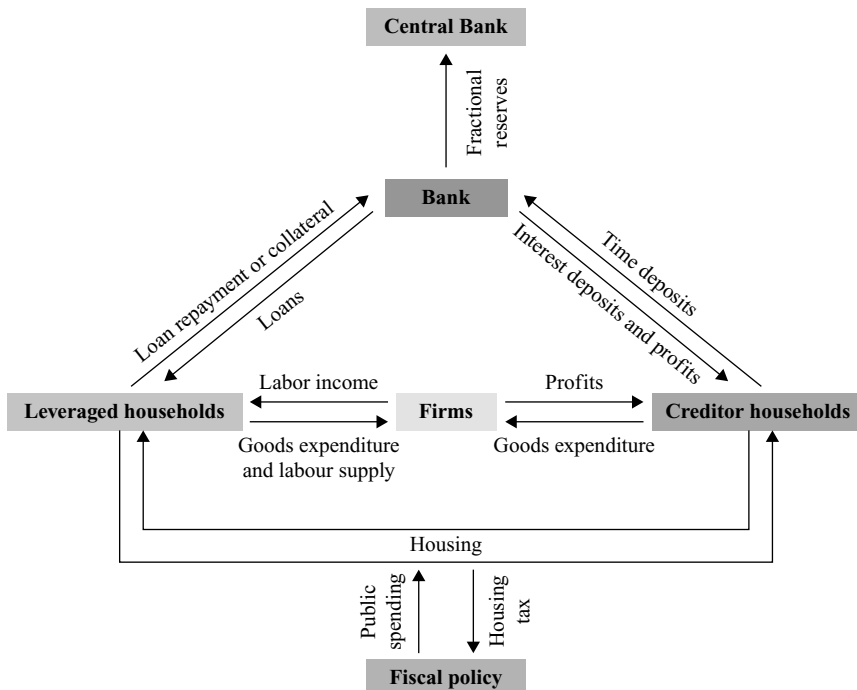
Source: Chadha et al. (2013c).

Figure 10 Government debt sales and economic activity

growth. In this sense, given that the amplification to expansionary policy in a recession has the potential to drag growth down in an expansion, any view of the value of these policies must be tempered with the knowledge of their future costs.

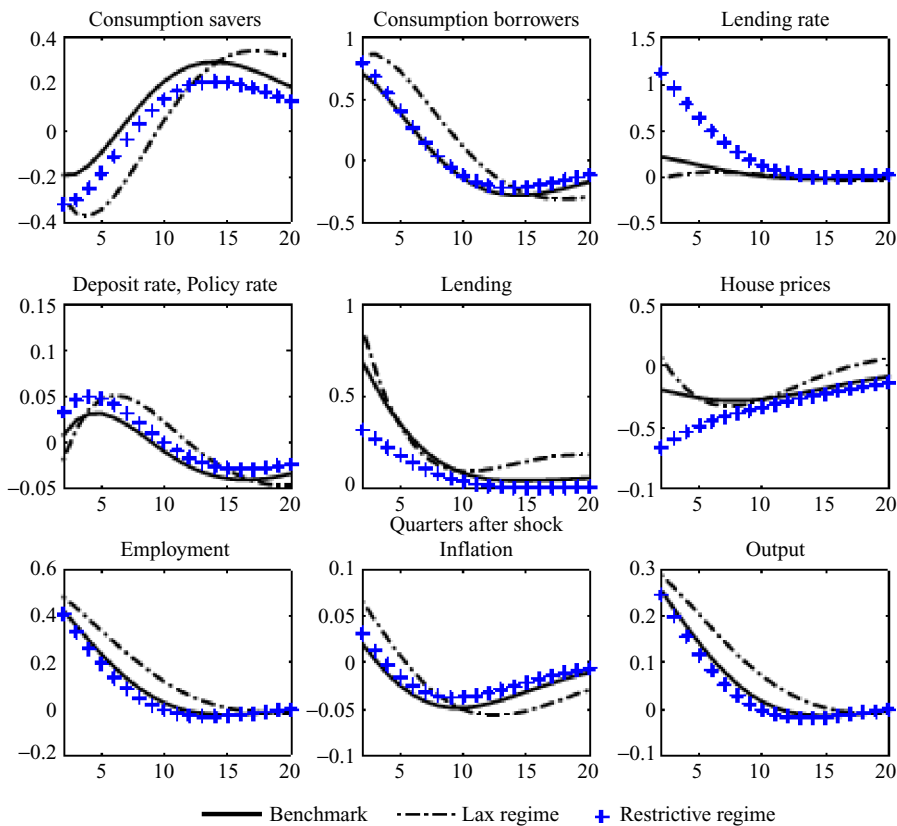
6 LENDER–BORROWER MODEL

Finally, in Chadha et al. (2013a), we unbundle the representative agent assumption and consider two household types: savers and borrowers. Saver households maximise their life-time expected utility subject to a standard cash-in-advance constraint (CIA), but are otherwise asset rich as they own the housing stock, financial intermediaries, firms and government bonds and behave as standard intertemporal optimising consumers. Borrowers face the same CIA constraint but obtain loans from banks up to the expected loan-to-collateral value of houses. Banks intermediate between savers' deposits and loans to borrowers on the basis of house prices, for which we derive an explicit demand function. We are thus able to analyse the interaction between both types of households and banks, and to assess the role of various policies in maximising household welfare. Figure 11 gives a schematic representation of the model, while Figure 12 shows a 1 per cent shock to the loan-to-value ratio, a so-called collateral shock. The higher is the loan-to-value (LTV) ratio, the higher is the marginal amount of new lending that can be accorded for a given value of the collateral (housing). The quantity of loans-to-borrower households



Source: Chadha et al. (2013a).

Figure 11 Banks in a borrower–lender model



Source: Chadha et al. (2013a).

Figure 12 Shocking the loan-to-value ratio in a borrower-lender model

then jumps up as housing demand rises, driving up the spread between the lending rate and the policy rate. Borrowers' consumption increases as a result of increased leverage and drives a temporary boom. But in this calibration the lending boom is short-lived and in later periods, borrowers are paying back their loans and gradually reducing the level of loans, which depresses output. The savers in the benchmark scenario reduce current consumption following the increase in the saving deposit rate. Note that under the restrictive regime the quantity of lending is considerably less and the lending rate considerably higher, and that house prices actually fall as the higher LTV means that there is less incentive to use houses as collateral.

The model captures the salient features of aggregate consumption dynamics and their apparent relationship to house prices, as it delivers strongly procyclical house prices with no wealth effects. We show that house prices, which are forward-looking, are closely linked to the path of borrowers' consumption, LTV ratios, inflation and the lending rate. Secondly, consumption dynamics are shown to follow a higher-order process when there are two types of households. Saver households have considerable volatility injected into their consumption titling plans by movements in real deposit rates. Borrower

households need to generate sufficient collateral to allow credit to flow to them in the form of loans and these loans then suppress consumption in future periods and lead to a cycle in aggregate consumption. There are also spillovers in this economy from one type of consumer to the other, as changes in the expected price of durable goods will affect borrowers' consumption via bank lending; the complementarity between consumption of the two types originates from the response of the monetary policy rate which, in our model, directly affects the deposit rate and savers' consumption decisions. Finally, we also consider the appropriate role of monetary and macro-prudential policies in stabilising this economy; specifically, we can use the model to understand the scope of instrumental control on financial activities and to understand the steady-state implications of policy-induced changes in the reserve requirement, risk-weighting of assets and the loan-to-deposit ratio.

7 CONCLUSION

Modern macroeconomics has frequently been criticised for its apparent inability to model financial questions. From the equity premium puzzle to the dominance of the representative agent, questions of risk and asymmetric information seem to have been side-stepped in our need to match aggregate behaviour with recourse to shocks rather than structure. The global financial crisis has provided a substantive incentive to develop models with financial frictions. And to some extent, and with a limited departure from neoclassical micro-foundations, I would argue that macroeconomics has risen to the challenge. I am not sure that this work has driven from any need to increase the external realism of macroeconomic models, rather to introduce structures that allow financial developments to feed back substantively into agents' decision rules. This short overview explores how the baseline NK model has been extended and illustrates these extensions by way of drawing impulse responses. It also examines the impact of open-market operations in these new models.

In these models, the set of interest rate premia that lead to market clearing in money and credit markets are closely linked to bank behaviour and to the evolution of asset prices. It was as a by-product of the need to understand and develop models of non-conventional monetary policy that models were developed with either preferences for assets of different maturities, loan production functions or bank capital to understand the evolution of financial frictions. We can now also break up representative agents into lenders and borrowers and consider in detail the underlying disaggregated consumption paths of these two types of agents. And yet we neither have agreement on how to break up lending and borrowing in the private sector nor on the role of the state and the private sector in wealth creation, because in aggregate we would like to develop models in which there is considerable amplification of economic shocks at the level of the balance sheet.

The nexus of finance, debt and asset prices means that it is highly probable that in order to develop macroprudential instruments we may have to conjoin fiscal, monetary and banking theory into one. Specifically, this means that the government's present value budget constraint has to be consolidated with that of the central bank and the intermediation role of banks between savers and borrowers may involve contingent claims on the state and the creation of debt levels that have a non-neutral impact on both aggregate demand and supply. There is therefore much exciting work to be done, and for the micro-founded macroeconomists this is no time to learn another 'language'.

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