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HOUSING MARKET DYNAMICS AND MACROPRUDENTIAL TOOLS

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Abstract: Against the background of the subprime crisis, where housing was implicated in the financial crisis in countries such as the US, as well as the ongoing discussions regarding Basel III, we survey the literature on housing market dynamics with a view to finding possible links to banking crises as well as potential macroprudential tools for dampening disruptive tendencies. We then go on to estimate house price equations and evaluate NiGEM macromodel simulations for Sweden with the same aim. Light is cast on the appropriateness of macroprudential intervention in housing, possible instruments to employ, and the interrelation of macroprudential with monetary policies.

Keywords: Macroprudential policy, bank regulation, house prices, housing markets

JEL classification: C52, E58, G21

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1 Introduction

The issue of housing bubbles, banking crises and monetary policy has returned to the fore with the subprime crisis. It is clear that the collapse of house prices in the US was a trigger for the crises, operating domestically via losses on banks' balance sheet and globally via securitised housing loans. This episode has led to a renewed debate on bank regulation, and notably on macroprudential policy. It is widely agreed that capital levels of banks have to rise, and also that it would be appropriate for some countercyclical element to be introduced into bank regulation, in order to offset the natural procyclicality that has been seen in this and many previous boom-bust cycles. However, the Basel proposals are for the most part based on tools with an economy wide effect based on capital or provisioning on the whole of banks' balance sheets. There remains a tradition, which has been continued in some Eastern European and Far Eastern countries, of applying countercyclical tools to the housing or commercial property markets alone, notably via controls on loan-to-value ratios. This raises the question of whether such tools could be appropriate for advanced OECD counties such as Sweden, what their incidence would be and how they would relate to monetary policy.

In order to address this overall issue, we provide an overview of work on the housing market, particularly as it links to monetary policy and financial stability. We also survey existing use of macroprudential policies in the housing market and related empirical work and undertake estimation of house price equations with a view to seeing what evidence they provide on possible impacts of such policies. Finally we undertake extensive simulations of the NiGEM model for Sweden in order to assess the macroeconomic impact of such policies and their relationship to monetary policies.

Accordingly, the paper is structured as follows. In Section 2 we provide a survey covering, the relationship of house prices to financial instability, macroprudential surveillance and monetary policy. In Section 3 we look macroprudential tools applicable to the housing market, notably loan to value (LTV) ratios but also debt service/income caps, capital weights on housing lending, dynamic provisioning and sectoral exposure limits. We note that current Basel proposals (higher overall capital and procyclical capital weights) do not bear specifically on the housing market. Section 4 completes the survey sections by giving an overview of econometric work on house prices which is essential to evaluating policy proposals.

Section 5 shows estimation of house price equations for Sweden and in a panel of OECD countries, based on the approach of authors such as Muellbauer and Murphy (1997 and later). Variables assessed include demographics, income, the housing stock, interest rates, and lagged house price rises. We consider whether credit enters these models and what other significant variables could be affected by macroprudential policies. Finally in Section 6 we consider the interaction of macroprudential policies and monetary policy. Apart from surveying the few papers which look explicitly at the impact of macroprudential policies on the economy as a whole, this section is focused on NiGEM simulations comparing macroprudential policies and monetary policy for Sweden with a newly estimated house price equation from the current exercise.

Throughout, we seek to keep in mind the overall aims of the project, for example to describe which macroprudential instruments - new, applied or proposed internationally - may be better suited than the repo rate to counteract excessive risk taking, increased indebtedness among households or extreme deviations of house prices from a long-term trend; to examine which macroprudential tools could be applied in Sweden and under what circumstances such tools should be used, and to assess how monetary policy tools can be coordinated with the macroprudential tools.

2 House prices, banking crises and monetary policy

2.1 Introduction

The connection between asset prices and banking crises was established in the seminal work of Kaminsky and Reinhart (1999), as well as Borio and Lowe (2002). Since then specific linkages between house price dynamics and banking crises have been discussed inter alia by Reinhart and Rogoff (2008) and empirically quantified by Barrell et al. (2010a). In the wake of the sub-prime crisis, policy makers such as Turner (2009) have increasingly turned their attention to the role of housing markets.

From an early stage in the development of macroprudential surveillance, there have been recommendations to focus on housing (BIS, 2000). Such recommendations include the monitoring of house prices down to a sectoral level due to the high concentration of banks' asset portfolios in this market (IMF, 2000) and their exposure to boom and bust cycles.

There is an ongoing debate as to whether house price bubbles should be targeted by monetary policy given their connection with financial instability. Again this reflects the increasing recognition that house price behaviour is ignored at the policy maker's peril although central banks often consider house prices as inappropriate targets except to the extent that they influence consumer prices in the relatively short run.

Meanwhile the subprime crisis has entailed a new focus on the possible use of tools for macroprudential policy to directly affect housing markets. These include loan-to-value ratios, loan to income limits and sectoral exposure limits for banks. These have been applied in countries such as Hong Kong (CGFS 2010) posing the question whether they might be appropriate for advanced OECD countries as well.

In the light of these developments, a need to be able to explain house price behaviour has become crucial for regulators to be able to mitigate the social costs of crises. Moreover given the changing nature of financial intermediation within increasingly competitive banking systems and structural shifts in demographics, migration and building regulations, the modelling of house prices is important in its own right. One important conclusion is that more resources must be devoted to collecting and disseminating data on house prices and related variables such as loan to value ratios since accurate house price modelling requires such information.

This section is structured as follows: in section 2.2 we explore the linkages between house prices and financial instability which justifies the recommendations of section 2.3 where the monitoring of house prices as part of macroprudential surveillance is discussed. Section 2.4 summarises the debate on whether central banks should pursue the twin objectives of price stability and financial stability in which case they may be required to respond to house price bubbles. Section 2.5 reviews the linkages between house prices and consumption since these are important channels by which regulatory changes to house prices could impact on aggregate demand. Thereafter in Section 3 we look at experience in using macroprudential policies in the housing market, and in Section 4 we focus on house price estimation both in the long-term and short-term. In this context, the user cost of housing which is central to house price estimation is discussed at length. A selection of alternative estimators in the literature is also briefly reviewed.

2.2 House Prices and Financial Instability

Much of the seminal work on banking crisis determination such as Demirguc-Kunt and Detragiache (1998, 2005) simply does not assess the link from banking crises to housing markets owing to a lack of house price data for most emerging market countries. Nevertheless, a connection between asset prices in a broad sense and banking (and currency) crises was established empirically by Kaminsky and Reinhart (1999) although they focused mainly on equity prices. Using a dataset containing 76 currency crises and 26 banking crises between the 1970s and 1995, they identified abnormal behaviour in stock market returns in the run up to banking crises. Their results showed that equity returns prior to banking crises were driven by possible asset price bubbles; returns 9 months prior to banking crises were 40% higher than their "tranquil period" levels.[2] The authors note that these results accord with Gorton (1988) and Calomiris and Gorton (1991) who view the bursting of an asset price bubble as a stylistic occurrence associated with banking crises: depositors who observe increases in firm failures in periods preceding the crisis form conditional expectations of impending recession and change their perceptions of the riskiness of their bank deposits accordingly.

Borio and Lowe (2002) and subsequent work by the BIS has also linked banking crises to asset prices, although their main focus has been on role of credit gaps (i.e. gaps between the credit/GDP ratio and its long-run trend as shown by a Hodrick-Prescott filter). Their asset price variable, which they consider helpful in prediction albeit poorer than the loan variable has tended to be a similar "gap" based on the average of equity, housing and commercial property prices. Their methodology, like that of Kaminsky and Reinhart (1999) has been the "signal extraction" approach.

More recently Reinhart and Reinhart (2008) have examined the link between capital inflows and banking crises by focusing on the behaviour of asset prices in emerging markets. They argue, along the lines Calvo et al. (2003), that to a large extent, capital inflow surges that precede crises are driven by foreign demand for a country's equity and housing as investment vehicles. Like Kaminsky and Reinhart (1999), the results of Reinhart and Reinhart (ibid) suggest that asset market collapses precede crises.

Reinhart and Rogoff (2008) extend the Reinhart and Reinhart (2008) analysis in the context of residential property prices. They examine 16 countries that experienced a banking crisis according to the dating proposed by Reinhart and Reinhart (ibid). Their data also reveals significant increases in property prices in the run-up to the sub-prime episode, with this trend being particularly marked in the US.

The above findings are corroborated by description in the Turner Review (2009) which suggests that in the context of the sub-prime crisis, historically low interest rates fuelled credit expansion and consequent property price booms in the US and UK. In the UK the housing boom was exacerbated by rising demand for housing coupled with inadequate physical supply and between 1997 – 2007 total mortgage debt relative to GDP rose from 50% to 80%. Lending decisions were driven by the perception that high LTVs were defendable because continued house price appreciation would erode borrowers' debt burdens. In the US, lending patterns were similar but driven by the need to direct credit to previously excluded social classes.

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[2] In contrast, currency crises were preceded (by about 18 months) by returns that were 40% below those observed during non-crisis periods; the authors attributed this to a downturn in the economic cycle. The results suggested that asset returns had already fallen below their cyclical peaks when currency crises materialised.

Against the background of suggestions regarding the predictive power of property prices for banking crisis occurrence as described above, Barrell et al. (2010a), published in the Journal of Banking and Finance have recently tested the usefulness of property prices as a leading indicator of banking crises. Using the logit approach common in the Early Warning System literature (see Demirguc-Kunt and Detragiache, 1998, 2005) they tested the predictive power of previously unused variables such as bank capital adequacy, liquidity and residential property price growth against more commonly utilised determinants in the literature. Based on a sample of 14 OECD economies covering the years 1980 – 2007, which included 14 systemic and non-systemic banking crises, they concluded that bank capital adequacy, broad liquidity and residential property price growth are the most important determinants of crises in the OECD.

Moreover, Barrell et al. (ibid) were able to quantify the marginal impact of house price fluctuations on the probability of banking crisis materialisation. For a given level of bank balance sheet health, a one percentage point rise in real house price growth was sufficient to raise the probability of a crisis by at least 0.07% (US) and by as much as 0.74% (France).

They note that their results accord with those of Borio and Drehmann (2009) and Borio et al. (2010) who utilised a signal extraction methodology to establish that property prices are leading indicators of banking crises. Whereas the Borio et al. (ibid) did not subject their model to extensive robustness tests, Barrell et al. (ibid) used a series of robustness tests, including out-of-sample crisis prediction, to show that house price dynamics have an indisputable role in the generation of financial instability. The social and public policy implication of this result, in the context of the earlier literature, is that house prices should be subject to monitoring as part of macroprudential surveillance, and possibly also control via macroprudential regulation.

Note however that predictive power over banking crises does not necessarily entail causality, if for example it is commercial property losses, correlated with house prices, that tend to bring down banking sectors. Rising commercial property prices drive credit availability and fixed investment in the upturn (the financial accelerator) and then when prices fall commercial property companies are most likely to default. In contrast, in most OECD countries, housing lending is recourse based, in other words there is a lien of the lender on household income to make up for any shortfall in the case of repossession. This may limit the impact of "negative equity" on defaults except in countries such as the US where lending is non-recourse and handing in the keys to the house covers the borrower's liability. On the other hand there may be important wealth effects on consumption (Davis 2010) which mean falling house prices drive defaults across the economy more widely.

2.3 Monitoring House Price Bubbles as Part of Macroprudential Surveillance

Macroprudential surveillance (MPS) can be defined as policy that focuses on the financial system as a whole, and also treats aggregate risk as endogenous with regard to the collective behaviour of institutions. It aims to limit system-wide distress so as to avoid output costs associated with financial instability (Borio 2009; Davis and Karim, 2009). To this end, variables that are systematically correlated with crises are monitored on a rolling basis by policy makers with the idea that aberrance in their behaviour can trigger policy intervention to mitigate potential financial instability. In other words there may be transmission of macroprudential surveillance into macroprudential regulation whereby outcomes of surveillance are institutionalised as part of the regulator's strategy for ensuring financial system soundness.

The definition above allows for a wide variety of surveillance techniques to become part of the arsenal against banking crises; both qualitative and quantitative aspects of the financial system should be monitored so that tools such as early warning systems form one component of the surveillance regime. Surveillance can also be distinguished at a micro bank level or at a systemic level. Regarding the former, Davis (1999) suggests monitoring of variables relating to bank balance sheet health as well as measures of their income and expenditures. In contrast systemic risk should be monitored by tracking aggregate variables such as non-financial sector debt, leverage and asset prices.

Given the discussion in the preceding section it is therefore surprising that the monitoring of house price trends and bubbles has not formed an explicit component of surveillance strategies to date in many countries. On the other hand, it could be argued that regulation is backward looking in that MPS needs are updated in the wake of crises as new information on the causes of crises emerges. This may explain why there is an increasing recognition that house price monitoring should form part of the MPS toolkit.

According to Whyte (2010), the emergence of property price bubbles prior to the sub-prime crisis occurred in countries such as Spain and the US which had distinct regulatory frameworks. This suggests property price evaluation may be a missing component in the MPS frameworks of many OECD economies. IMF (2000) notes that real estate prices should be monitored at a sectoral level because banks often concentrate their portfolios with loans against properties the prices of which display boom and bust cyclicality. A recent example of this in the UK was lending for “buy-to-let”. In this context the authors also recommend monitoring of household indebtedness since a large fraction of this is related to mortgage obligations. However there is recognition that this enhanced monitoring system is subject to data availability which is currently limited and that more resources are required to collect and disseminate data such as residential property prices and loan to value ratios.

One point to note regarding MPS and house prices is the difficulty associated with measuring house price bubbles. As will be discussed in section 4, the estimation of house prices has broadly followed two paths: the asset pricing approach and the cointegrating approach. The former methodology essentially uses a time series of house prices to determine whether prices are over or undervalued but the lack of a structural model implies the degree of price misalignments is a rough guide only. The cointegrating approach assumes house prices are driven by fundamental factors but there is limited consistency in the literature on the exact nature of these determinants; different authors use different specifications based on their theoretical motivations and data availability (see Section 4). This heterogeneity in estimation means the determination of house price bubbles is operationally difficult. On the other hand if standard “bubble” estimation tools are employed such as comparison with long term trends using Hodrick-Prescott filters, the bubble estimate becomes subject to the same criticisms as output gap measures or even measures of credit gaps. Hence although the monitoring of house price bubbles may be an important principle of MPS, in practice policymakers may need to form a consensus on acceptable bubble estimators.

The lack of adequate historic data on house prices may explain to an extent why new regulatory proposals (e.g. BIS 2010) advocate countercyclical provisioning against credit in aggregate, since authors such as Borio and Drehmann (2009) and Drehmann et al. (2010) contend that credit cycles may cause property price cycles,[3] although they also maintain that credit is a better direct indicator of banking crises than asset prices. The suggestion that credit

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[3] Evidence in Barrell et al (2011) suggests this is not the case in most OECD countries, rather, it is property prices that drive credit. Davis and Zhu (2010) found a similar result for commercial property prices

has a primary role in the transmission mechanism of banking crises may stem from the observation that rapid credit growth precedes banking crises during a phase when collateral values are high and credit risk is improperly processed. It also may relate to developments in both house prices and commercial property prices.

Although empirically many studies appear to find credit growth to be a leading banking crisis indicator (Demirguc-Kunt and Detragiache, 1998, 2005; Borio, Furfine and Lowe, 2001), Barrell et al. (2011) shows that there is no conclusive empirical evidence that credit Granger causes property prices. In this sense although credit growth is an important MPS variable in its own right, it cannot be a substitute for property price monitoring.

Furthermore, Barrell et al. (2010b) show that a logit model using house prices, capital adequacy, liquidity and the current account (i.e. slightly extending their earlier work) could have predicted the subprime crisis in the UK, US, Belgium and France using an estimate for up to 1997 only. They contend that the recursive forecasts their model provides should be a key input to macroprudential surveillance as well as giving important evidence for macroprudential regulation.

There remain some difficulties with using house prices for surveillance. With respect to house price cycles, there is little consensus on definitive estimators that can be used to identify trend levels and deviations from trend (this is discussed in more detail below). However the same estimation problem applies to credit analysis where the cyclical components are often computed with a degree of subjectivity. Given that similar limitations apply to the estimation of credit and house price cycles, there is little reason to exclude house price monitoring from the next generation of MPS frameworks. Moreover if property prices are not subjected to robust monitoring in future, it is possible that signs of financial instability will be missed and that societies will re-incur the costs of banking crises. In recognition of such costs, a debate has formed on the merits of including asset prices, including house prices, in monetary policy rules. We turn to this issue next.

2.4 Asset Price Bubbles and Monetary Policy

Given the empirical connection between house prices and banking crises and the recognition that housing market developments should feed in to MPS, a natural question arises as to whether house price developments should also be the target of monetary policy, given that interest rates can influence house prices via a number of channels (see discussion of Mishkin (2007) below and Section 4)

Disysatat (2010) highlights the two crucial alternatives available to policy makers in this respect: one in which the central banks only responds to asset price misalignments if they alter the path of central bank targets (inflation and the output gap). The other alternative is that in recognition of the social costs of asset price corrections, central banks should counteract the accumulation of asset price imbalances irrespective of whether they are likely to impact on the short-term paths of inflation and output. This second approach has been used to justify why central banks should “lean against the wind” of asset price bubbles whereas according the first view, policy makers would deal with the aftermath of such bubbles in the wake of asset price corrections (leaning versus cleaning).

Hence the debate does not question the inflation targeting role of central banks but is concerned with more subtle aspects of stability such as the timing of interventions against asset prices and the relative weights given by policy makers to information contained in asset prices versus their targets. Fawley and Juvenal (2010) summarise the divergent views on this;

Bernanke and Gertler (2001) suggest monetary policy should restrict itself to targeting inflation whereas Cecchetti et al. (2002) believe asset price bubbles should be mitigated by central banks. In other words, the latter suggest central banks should be concerned with the "twin objectives" of monetary and financial stability.

Bernanke and Gertler (ibid) cite an earlier contribution (Bernanke and Gertler, 1999) in which they establish that the medium term inflation target announced by the central bank should be the primary anchor for monetary policy. Inasmuch as the inflation forecast already imbibes the forward looking expectations of asset prices, including house prices, central banks should not respond to asset price developments beyond this.

The empirical simulations of Bernanke and Gertler (1999) appear to validate this stance; they used a Taylor rule in which the change in the interest rate is dictated by a coefficient of 2 on the expected inflation rate. They found that this aggressive reaction function was sufficient for the stabilisation of output and inflation in situations where asset price bubbles emerged and then collapsed. On the premise that such a Taylor rule is adopted, the authors could not establish any additional benefits when central banks responded to asset price deviations. Moreover they argue that if central banks attempt to stabilise asset prices there may be detrimental effects on market expectations which are not always predictable and could modify monetary policy transmission adversely.

In line with the above, Bohl et al. (2004) suggest unpredictability could arise due to problems with estimating house price bubbles. They estimate Taylor rules for Germany, France and Italy and find that the addition of asset prices to the reaction function produces interest rate volatility along the lines of the results for Bernanke and Gertler (1999). However their GMM results which rely on asset prices as instruments generate Taylor rules which fit the actual data well, suggesting that although the central banks did not respond to asset prices directly they did respond implicitly as asset market developments affected expectations of the inflation and output gaps.

Fawley and Juvenal (2010) also note the problems with Taylor rules and house price bubbles. The latter are by definition episodes when house prices respond to irrational exuberance and thus it could be argued are unpredictable. In this case forward-looking rules could not accommodate bubbles effectively and even if a bubble is identified, the impact of an interest rate rise would not be predictable and would most likely generate interest rate volatility. Furthermore if linkages between asset prices and interest rates are weak, central banks would have a limited capacity to deflate housing market bubbles.

On the other hand Mishkin (2007) recognises the economic impact of housing market fluctuations can be severe and thus may warrant interventions by central banks. In other words, a financial crisis is itself a major disinflationary shock, the impact of which is appropriately allowed for. The recent experience of the US housing market where post-2006 contractions in residential investment reduced GDP growth by 1% over the preceding four quarters exemplifies the detrimental impacts of substantial property price corrections. He lists 6 transmission mechanisms whereby interest rate changes impact on house prices and consumption which are discussed further in Section 4: (1) the user cost of capital (2) expectations of house price movements (3) housing supply (4) wealth effects (5) credit effects on consumption and (6) credit effects on housing demand.

Whilst there is considerable uncertainty on the exact structure of these transmission mechanisms, Mishkin (ibid) indicates the relationships cannot be ignored by those setting monetary policy and that following rules based systems that do not recognise these linkages is inappropriate: if central banks aim to manage aggregate demand to stabilise inflation and unemployment they cannot ignore housing market developments.

According to the preceding view, a Taylor rule based system where interest rates respond to house price appreciation only once it is realised may not set the path of interest rates optimally because optimality would require the interest rate to accommodate expected house price changes. Empirical simulations verify this: the model which incorporates future price changes results in a more aggressive and rapid interest changes than the Taylor rule model. Moreover there is a considerable lag before changes in house prices feed through to changes in households' consumption which means central banks should have sufficient time to respond to price fluctuations. On the other hand in his 2007 paper Mishkin does not advocate "leaning" per se (although he has tended towards it in more recent work).

Cecchetti et al. (2002) strongly support the view that central banks should explicitly respond to asset price misalignments. They do however make the distinction between reaction and targeting: whilst they argue that central banks could improve macroeconomic stability by responding to misalignments not contained in the inflation forecast they do not advocate asset prices as actual targets. In line with the argument of Poole (1970) who suggested that by "leaning against the wind" of money market changes central banks could stabilise the macroeconomy, Cecchetti et al. (ibid) believe a similar approach should be used against asset price misalignments, provided that the source of this aberrance can be attributed to supply and demand for the asset itself.

In other words, they do not propose that central banks should respond to all asset price misalignments but only after an analysis of asset price behaviour suggests some corrective action would be prudent. In this sense, the authors' arguments complement the arguments put forward in the preceding sections on macroprudential surveillance and the empirically established connection between financial instability and house prices. Wadhwani (2008) suggests that the Swedish authorities "leaned into the wind" in the manner that Cecchetti et al (2002) recommended, and this may account for lesser difficulties there than elsewhere.

Disyatat (2010) adds to the debate by constructing a model using standard transmission mechanisms with the focus on the operational aspects of central banks' remits. In other words, explicit Taylor rules are not derived since as the author points out, these reduced form rules prevent flexibility in the central bank's response. Instead, the author uses a non-restrictive approach whereby the central bank is assumed to face an economy characterised by three equations describing the evolution of inflation, output and asset prices. These then give rise to the optimal policy response; the author shows that to the extent that asset prices impact on inputs to the central banker's loss function (output gap and inflation), asset price misalignments require some intervention.

An important issue in this context is that the above choice whether or not to respond to housing market developments is only feasible for countries whose monetary policymakers are able to respond. This rules out those who have a currency board, fixed exchange rate or monetary union. It is particularly in the latter context that interest has arisen in specific macroprudential instruments to control the housing market, as discussed in Section 3 below. First we briefly consider the relation of house prices to consumption in the context of monetary and financial stability.

2.5 House Prices, Consumption and Policy Concerns

There are divergent views on the extent to which house price changes eventually impact on consumption. These issues are important from the perspective of regulators since depending on the exact transmission mechanisms, house price changes and associated financial crises may have different impacts on aggregate demand via consumption, while falling consumption may itself aggravate crises via bankruptcies of firms involved in producing consumer goods and services, as well as unemployment.

As noted above, Mishkin (2007) lists six transmission channels by which monetary policy decision can impact on house prices: via (1) the user cost of capital (2) expectations of house price movements (3) housing supply (4) wealth effects (5) credit effects on consumption and (6) credit effects on housing demand. While the first three channels reflect the direct impact of interest rate changes, the last three channels are indirect.

The impact of interest rate changes on the user cost of housing is apparent from the user cost functions described below which are also discussed in the context of the role of expectations of house price appreciation and impacts on supply. In Mishkin (ibid), wealth effects according to life-cycle theories of consumption, should arise because households disregard the source of increased wealth (whether from appreciation of financial or real assets) and increase consumption according to their marginal propensity to consume.

However there is the alternative view that wealth changes from different sources will have different impacts on consumption because of the demographic distribution of these assets: financial assets (such as stocks) are more likely to be held by the rich and old whose marginal consumption propensities are lower and so stock price appreciation will have a smaller impact on consumption than house price appreciation. Also the relatively lower volatility of house prices compared with stock prices could mean that house price appreciation is viewed as being more permanent and therefore leads to larger changes in consumption behaviour.

On the other hand it is possible that house price increases could lead to lower current consumption because the price appreciation is associated with a higher user cost of housing in which case non-residential consumption suffers; those wishing to purchase housing will now have to save more and consume less. Moreover a rise in stock prices is a stronger signal of increased future productivity than house price appreciation because the latter could arise from supply side constraints and not because future economic prospects have improved. In this case, stock price appreciation could lead to higher consumption especially since older generations, according to life cycle theories, have higher propensities to consume and tend to hold more stocks than younger households.

Muellbauer and Murphy (2008) argue there should be no wealth effect per se from house price appreciation based on estimations in Muellbauer and Murphy (1989) and Aron et al. (2007). Instead there is a collateral effect when house prices rise whereby positive equity is translated into higher household borrowing. This, they argue is important in explaining the empirical reality of higher consumption following house price appreciation which is contrary to predictions based on the life cycle hypothesis. In their view the latter suggests that when house prices rise, consumption should fall due to higher deposit requirements on house purchases.

Thus the credit channel is an important reason as to why increased house prices may lead to higher consumption. In poorly developed credit markets such as Italy, Muellbauer and Murphy (ibid) argue that households cannot translate positive equity into loans and consequently house price appreciation is associated with lower consumption. Conversely in deep mortgage markets such as the UK and US, greater competitiveness means borrowers benefit from higher loan to value ratios and thus need to save less to finance new house purchases. Moreover, existing homeowners can release equity easily due to the depth of credit markets. In combination these effects lead to an increase in consumption when house prices rise.

Buiter (2010) elaborates further on the wealth effect debate. He argues that housing assets are no different from any other durable asset, whereby self-sufficiency means price effects have no impact. In other words, if the owner does not plan to sell or buy a property and has the desired lifetime level of housing services, then they are indifferent to price changes since wealth and the cost of the stream of services change by the same amount. In reality agents are often not self sufficient and are affected by price changes in different ways; if prices fall, owners are worse off to the extent that the fundamental value of the house is less than the discounted value of the housing services they wish to consume in their lifetime; those who are outside the market at present will in contrast be advantaged by house price declines as they can buy housing services more cheaply.

Buiter (ibid) argues that representative agent models cannot distinguish between the two ownership categories described above and therefore contends that there is no net housing wealth effect. If however, a heterogeneous agent model is used then the differential impacts of house price changes on non-owners, landlords and owner-occupiers can be established; the aggregate consumption change then arises from the redistributive effects between agents who have different marginal propensities to consume (Woodford 2010). The implication of the heterogeneity in housing consumption is important for regulatory purposes. If in aggregate house price changes do alter consumption, and thus aggregate demand, there may be a case for policy makers to avoid large swings in house prices especially as these may generate financial instability both directly (via mortgage defaults) and indirectly (via the impact of lower consumption on producers' solvency and unemployment).

Finally, Davis (2010) surveys empirical work on consumption and house prices and concludes that the empirical evidence for tangible wealth effects as well as financial wealth is well supported. This underlines the importance for all countries to ensure that there is adequate, accurate and timely data on the complete balance sheet of the household sector. He notes that arguments for different long-run housing wealth effects across countries are arguably stronger than those for net financial wealth, given the wide differences in housing finance systems. On the other hand, there remains some evidence, notably at the micro level, that the housing wealth effect is actually an income-expectations effect.

Note again that this effect on consumption is quite distinct from the possible losses that mortgage lenders may make as a consequence of homeowners defaulting on their loans. It may nevertheless be an indirect cause of financial instability, since falls in consumption may give rise to general recession leading to widespread job losses and business failures. Accordingly, it could justify monetary policy concerns over house prices as well as macroprudential regulation which addresses housing valuation concerns. It is to use of such macroprudential policies that we now turn.

3 International experiences of macroprudential policies related to housing

3.1 Overview

Whereas macroprudential surveillance focused on house prices as a key indicator is common across many countries, attempts to regulate house purchase lending are less widespread. It is also contrary to the thrust of Basel discussions which is focused on general macroprudential instruments, notably capital or provisions held by institutions (either in time series or cross section) rather than sectors they lend to. Under it, national regulators have scope to set an additional capital buffer of 2.5 percentage points for banks, which rises when times are good and falls when they are bad. And the suggestion in Basel Committee (2010) is that such buffers should be calibrated to credit "gaps" [4]. The Basel approach builds on the historically less interventionist approach of regulators and central banks in OECD countries, who have until recently taken the view that interest rates and individual bank capital regulation are all that is needed for both monetary and financial stability to be maintained.

That said, there has been quite extensive use of housing market related macroprudential regulation by non-OECD countries and some lower income OECD countries. As outlined in this section, methods that have been applied include limits on loan to value (LTV) ratios, debt service/income caps, dynamic provisioning related to housing lending and sectoral exposure limits. And in the light of the sub-prime crisis there is increased interest in what can be called specific macroprudential instruments, see in particular CGFS (2010), also Harding (2010).

3.2 LTV limits

According to CGFS (2010), the most widely used specific instruments have been those limiting credit supply to sectors such as housing or commercial property seen as vulnerable to excessive credit growth. The most common approach is the control of LTV ratios. This has been used in particular in Asian countries such as Hong Kong, Korea, Malaysia, Singapore and India. China, Thailand. Bulgaria, Romania and Croatia have also imposed such limits (Borio and Shim 2007). These limits tend to start from a typical "normal" level in the economy from a microprudential point of view such as 80%. Then they would impose a tightening beyond that of 10 or 20 percentage points.

Most recently the Swedish Financial Regulatory Authority capped the mortgage LTV at 85%, while Hungary, Finland and Norway have also declared that LTV policies will be introduced. Whilst the motivations for such caps are diverse (in the case of Sweden consumer protection is a large consideration, elsewhere it is often financial stability) it is likely these measures will be beneficial for systemic stability, although it is too early to evaluate the exact effectiveness of these policies.

Such limits have historically tended to be chosen in economies that had a heavy exposure to financial cycles both in terms of the macroeconomy and the financial sector. They would also have housing markets that responded strongly to credit availability, having incipient excess demand. Often fixed or managed exchange rates limit the use of monetary policy for stabilisation purposes in these countries (which makes it a paradox that they have not to date been considered in euro area countries). LTVs might be complemented by other policies which seek to ensure prudent lending such as limits on loan to income and loan concentration, on the grounds that a single policy could not address all the elements of risk in a transaction. The intended use of LTVs was to enhance financial sector resilience and leaning against build-ups of risk both at micro and macro levels, although as noted they can also be motivated by consumer protection. According to central banks and regulators which use them, LTVs are seen to directly influence credit growth and also provide a clear signal of concerns by the authorities to institutions and the public.

The level of the cap needs to take into account expected volatility and overvaluation of house prices as well as political economy considerations (that it is difficult to impose very low caps)

[4] Like the output gap, the credit gap measure is the distance between credit levels at time t and the long-run trend as (usually) measured by a Hodrick-Prescott filter.

and the tolerable level of loss given default. A risk with an LTV cap is to make the maximum level also a minimum and thus raise the LTVs on new lending. Judgement is the main basis for adjustment in LTV caps, although one country does calibrate it to quantitative indicators such as growth in home sales, real estate investment and house prices. Further information needs are for surveys which show the extremes of the distribution, and the riskier products (e.g. subprime) and new distribution channels that may be missed by conventional statistics.

On the other hands, there is a risk that LTV limits are circumvented by strategies such as offshore borrowing, unsecured borrowing, financial engineering, falsification of asset valuation or other borrowing from outside the regulated financial system. Scope for cross border lending is a particular challenge in small open economies. Such problems could however be avoided by simply making the portion of loans above a regulatory limit non-enforceable in the case of default (Weale 2009) – a policy that has not been tried to our knowledge at present. Institutions would then have a strong incentive to hold to the LTV limit, and check consumers against credit registers.

In addition, it should be noted that LTV limits are not strictly countercylical since the ratio depends on an endogenous variable (house prices). Some would argue that limits on debt servicing ratios would more sensitively address the issue of households' burden of debt and hence likelihood of default.

Measuring the success of LTV policies could be done by assessing the growth rate of credit, assuming the objective is mainly to lean against the financial cycle. It is not however easy to distinguish from the effects of monetary policy, confidence and income growth expectations in driving borrowing. There appears to be less evidence that LTVs are effective in promoting lending in a downturn than restraining it in the upturn. If the aim is to increase resilience, then total housing equity (and especially of recent loans) as well as banking sector capital adequacy would be relevant and LTVs may be helpful in providing buffers. CGFS (2010) seems to suggest that the success in this latter aim has been greater than in restraining credit expansion. There is also little evidence at present that LTV limits can restrict house price growth per se.

Hong Kong has no scope for raising interest rates due to the fixed rate vis a vis the US dollar. Accordingly, macroprudential instruments were seen as essential to prevent banking crises following property bubbles when the US interest rate was "too high" for domestic conditions in Hong Kong. There were successive decreases in the maximum loan to value ratio in the 1990-7 period, from 80-90% to 60%. Although the Asian crisis came after the last tightening, with a marked fall in the price of housing, the banks remained solvent given the low LTVs on their loans. This limit was complemented by a maximum limit of 40% of assets to be held in the form of mortgage loans over 1994-8.

Wong and Hui (2010) comment that although property prices dropped remarkably by more than 40% right after the Asian financial crisis, the subsequent delinquency ratio for mortgages in Hong Kong never exceed 1.43%. They also suggest that a policy of mortgage insurance may need to be instituted to prevent excessive liquidity constraints on households and that that an effective operation of loan-to-value policy may require some discretion to adjust the maximum loan-to-value ratio.

Gerlach and Peng (2005) showed that the limits on LTVs had a detectable effect on the impact of house prices on borrowing in Hong Kong, with a 10% rise in house prices having only a 1.5% effect on lending compared to 4% before the measures. In earlier work (Gerlach and Peng 2002) they showed that there is both short-term and long-term causality running from property prices to lending but not the opposite, suggesting that the LTV limits did not restrain property prices per se.

The potential benefit of LTV caps is visible in countries such as the US where by some estimates 25% of loans currently suffer from negative equity, with a strong incentive to default. Meanwhile the structural features of the financial markets may also limit lending via LTVs, for example in Germany via Pfandbriefe which can only be used to securitise if they have LTVs of less than 80%. Fiscal policy may also impact on the housing market via LTVs.

Wong and Hui (2010) also look more deeply into the effectiveness of LTV limits in a panel of countries. They find that economies with LTV policy are estimated to have a lower sensitivity of mortgage delinquency ratios to property prices than those without LTV policy, taking into account other determinants of default (property prices, GDP growth, mortgage debt/GDP and interest rates), On the other hand, their model can be criticised from a robustness point of view, notably because omitted variation in regulations could underlie the results.

3.3 Other sector-specific macroprudential regulations

LTV limits are not the only form of regulation of the terms of credit that can be applied to the housing market. Debt service/income caps have also been tried in Hong Kong, Malaysia and Korea. For example in 2006 the Korean authorities imposed a debt repayment to income limit of 40% in specific areas where the price of luxury apartments had risen sharply. China imposed a wider limit in 2004 of 50% on loan interest/household income ratios, and Greece a 40% limit in 2005. In Malaysia in 1995 the monthly repayment for credit cards was raised from 10% to 15% of balances. In Thailand in 2005 credit card lines were limited to no more than 5 times monthly income. Such limits require there to be sufficient information exchange between banks and/or the existence of a central credit register.

Dynamic provisioning as applied in Spain since 2000 is applied to overall credit expansion rather than that in the housing market, but would naturally bear on housing credit when this is a large proportion of total credit, as has been the case in Spain in recent years. Banks set aside provisions during times when credit expansion is particularly rapid, which anticipates the losses to be realised when there is a downturn. The provisions are higher on riskier forms of loan. So for example at the end of 2007 the total accumulated provisions (close to 75 percent were general provisions) covered 1.3 percent of the total consolidated assets of Spanish deposit institutions, at a time that capital and reserves represented 5.8 percent of those assets (Saurina 2009).

The experience to date of this policy is that it has been more successful in the protection of the institutions than in limiting credit growth or the asset bubble, although the difficulties of the Cajas or savings banks shows that even this effectiveness is limited. We note that the parameters of dynamic provisioning could be adjusted to penalise certain types of loan since they fall into 6 different risk buckets, but the Spanish have not chosen to do this to date.

Some countries have explicitly varied capital weights to allow for concerns regarding the housing market. This enables banks to choose whether or not to lend to the sector judged to be growing too rapidly in the light of the amended cost of lending. They could react by absorbing the cost, raising more capital, and raising the cost of lending to the sector. At a macroeconomic level, it could be seen as widening the spread of mortgage loans over the deposit rate in the housing market, as the deposit margin can also be adjusted when capital requirements are raised (see Barrell et al 2009).

As noted by McCauley (2009) varying capital weights was an instrument used by the Indian central bank in late 2004, raising Basel 1 weights on mortgages and other household credit given rapid growth. The capital weight on mortgages was raised from 50% to 75% and that on consumer loans from 100% to 125% while commercial property lending had its weight raised from 100% to 150%. The consequence was a considerable fall in the growth rate of these loans, absolutely and relative to the total. Mortgage loan growth for example fell from around 70% in the year to March 2004 to 50% up to March 2005 and just over 40% in the year ending March 2006. Estonia imposed similar general increases in the risk weights on housing loans to residents in 2006.

Such limits can be conditional on LTVs as cited by McCauley (2009), in that the Reserve Bank of Australia permitted the 50% weight on mortgages to be applied only to loans with an LTV of below 70%, while Borio and Shim (2007) cite a rise in the Irish risk weight for the portion of mortgages over 80% LTV from 50% to 100%; Norway and Portugal imposed similar limits in the 1990s, and Bulgaria in 2004.

Implicit taxation of credit growth was applied widely in the pre-liberalisation policies in countries such as the UK and France, where rapid growth in lending attracted higher reserve requirements on the funding side. In Finland in the late 1980s there was a threshold set on loan growth with lending above that level attracting higher reserve requirements. This was considered successful in restraining lending growth relative to that in Sweden (Berg 1993), although it did not prevent the occurrence of a banking crisis in Finland. Bulgaria imposed similar limits in 2005. Latvia raised general reserve requirements in 2004 to restrain lending growth. The policy of penalising growth of banks balance sheets of over 20% set in Croatia in 2003-6 was also applied to general credit growth. Such policies could also be applied to the housing market. But banks with access to securities borrowing or foreign bank credit could avoid such restrictions.

Sectoral exposure limits were applied in Ireland in the late 1990s, which meant that only up to 200% of own-funds could be lent to a given industrial sector, while only up to 250% could be lent to two sectors, which shared the economic risks of an asymmetric shock, such as property and construction. But these evidently did not prevent sufficiently large exposures to lead to the current economic and financial difficulties that the country is facing. In Romania in 2005, foreign currency lending was set to be no more than 300% of own-funds.

Borio and Shim (2007) sought to evaluate the impact of macroprudential policies such as those summarised in this section on credit and asset price growth. They found that there was rapid growth in both these variables at the time the measures were introduced. They found that there were reductions in both credit growth (of 4-6 percent) and house price growth (3-5 percent) after the measures, although this it not always easy to divide the impact of such measures from that of monetary policy or economic growth.

Barrell et al. (2010b) looked at how house prices should impact on macroprudential regulation generally. Against the background of their logit model predicting banking crises cited in Section 2, as well as arguments that credit growth should guide countercyclical provisioning, they suggest that the appropriate adjustment for procyclicality requires the country to calculate the trade-off between house prices, current account balances and regulatory variables over time. Since there is nonlinearity in a logit equation, there is not a simple rule that can be derived. Undertaking a scenario with 5 pp higher house prices, they showed that the regulatory adjustment is greater, as would be expected, with higher lagged house price growth, but the relationship is not one-to-one – it depends also on the other regulatory and non regulatory variables in the model. A given growth rate of house prices is more threatening to financial stability when there is also low capital and liquidity as well as a current account deficit.

Whatever the context, it is clear that the correct modelling of house prices is crucial and is likely to receive increasing attention in the wake of the sub-prime crisis and policy developments; it is this issue we turn to in the next section. The determinants of house prices may either capture directly the impact of policy, or identifies key driving variables which would otherwise bias the results of estimation – and which may in any case be indirectly affected by policy in a macroeconomic context.

4 Extant work on Estimation of House Price Equations

House price estimation typically uses a first stage model which links house prices to a set of "fundamental" determinants. These in turn represent the factors that drive the supply of and demand for housing (Gattini and Hiebert (2010), Muellbauer and Murphy (2006, 2008), Capozza et al. (2002)). The justification of this approach is that house prices and fundamentals are cointegrated; this model then determines the long-run price of housing. Such fundamentals may include long run settings of policy variables.

The dynamics estimated in the second stage recognise that actual house prices deviate from their fundamental values in the short-run and attempt to accommodate these deviations through an error correction framework. This allows the examination of a host of factors that drive house price dynamics: bubbles, spatial and temporal effects and behavioural and informational drivers of house prices as well as short run variations in policy variables.

There has however been criticism of the cointegrating approach. Gallin (2006) notes that while there may be theoretical justification for a cointegrating relationship based on supply and demand, the same model explains why a cointegrating relationship may be absent: there is no reason to assume supply and demand elasticises are stable over time[5]. In other words, a test of cointegration implicitly tests the stability of these elasticities; however given the research time that has been devoted to their temporal and spatial variations, it may be that a cointegrating framework has been accepted too readily in the literature. Nevertheless, this methodology remains the dominant modelling technique[6] in the housing market literature and so we devote the rest of this section to discussing it in more detail.

4.1 The Supply and Demand Framework

According to Gallin (2006), house prices are cointegrated with their fundamental determinants if a long-run relationship exists and if this relationship can be characterised by supply and demand equations according to:

$$Q_d = D(Y, N, W, UC, \theta_d) \quad (1)$$

where Y = income
N = population
W = wealth
UC = user cost of housing
θ_d = other factors that shift demand

[5] E.g. due to regulatory changes in planning permission (affecting supply) or demographic changes (affecting demand).

[6] Other approaches include the VECM [Gattini and Hiebert (2010)] and spatio-temporal impulse responses to gage the degree to which shocks diffuse over time and space [Holly, Pesaran and Yamagata (2010)].

where both income and wealth are potentially influenced by monetary or fiscal policies.

We will discuss the user cost of housing in more detail later, but briefly in this context, the user cost of capital itself depends on the price of housing and other variables according to:

$$UC = P\left[(1-T_y)(m+T_p)+\delta - cg\right] \quad (2)$$

where P = house price
m = mortgage rate
T_y = income tax rate
T_p = property tax rate
δ = depreciation rate
cg = capital gains

where fiscal policy may affect taxes and also monetary policy the mortgage rate. We note that macroprudential policies may also affect the user cost via mortgage rates, for example if there are higher capital charges on mortgage lending. However, a high LTV may not affect the interest rate directly but rather may affect the "shadow price of housing" as demand for housing falls at a given mortgage rate owing to the need for more saving in order to pay a deposit.

The main influences on the supply of housing can be summarised as:

$$Q_s = S(P, C, \theta_s) \quad (3)$$

where P = house price
C = real cost of building
θ_s = other factors which shift supply

where monetary policy can affect the real cost of building via the interest cost of financing construction, while regulations affecting land use may also have an important influence on supply overall. Re-writing equation (2) as

$$UC = P \bullet A \quad (4)$$

means house prices are determined by the following set of "fundamentals":

$$P = f\left[Y, N, W, C, A, \theta_D, \theta_S\right] \quad (5)$$

In many studies, an explicit supply equation is not defined, rather, determinants of supply enter indirectly through the demand framework, e.g. Muellbauer and Murphy (2008) where the existing stock of housing impacts on house prices through the income per household variable.

In Cameron et al. (2006), θ_S is partially defined as an explicit equation describing the change in the stock of housing over time. This equation augments the supply and demand equations.

In Hott and Monin (2008), housing supply is modelled in the manner of McCarthy and Peach (2004) where housing supply (S_t) is a function of the depreciated existing housing stock (δ S_{t-}

$_{1}$) and any new builds that occurred over the period (B_{t-1}) as in equation (6). Housing supply is deliberately not related to house prices so that construction costs can be treated as an exogenous variable[7] although the authors recognise that alternative specifications are possible where construction costs positively affect house prices and the level of construction is endogenously determined.

$$S_t = \delta S_{t-1} + B_{t-1} = \delta^t S_0 + \sum_{i=1}^{t} \delta^{i-1} B_{t-1} \qquad (6)$$

In Muellbauer and Murphy (2008) and Cameron et al. (2006) the demand equation is inverted to model house price as a function of its determinants. This is akin to equation (5) and is formally derived from their demand curve specification as follows:

$$\ln\left(\frac{hs}{pop}\right) = \alpha \ln\left(\frac{y}{pop}\right) - \beta \ln r_h + \ln d \qquad (7)$$

where hs = housing stock
pop = population
y = real income
r_h = real rental cost of housing
d = demography

The final inverted demand curve is obtained by replacing the real rental cost (which is unobserved) in equation (7) with the real user cost of housing since the two are equal in equilibrium. The equation is then inverted to yield:

$$\ln(hp) = \frac{\alpha}{\beta} \ln\left(\frac{y}{pop}\right) - \frac{1}{\beta} \ln\left(\frac{hs}{pop}\right) - \ln(UC_h) + \frac{1}{\beta} \ln(d) \qquad (8)$$

where UC_h[8] is the real user cost of housing.

In practice, a restriction[9] is imposed by the authors to obtain the final estimated equation:

$$\ln(hp) = \beta_0 + \theta(\ln(y) - \ln(hs)) - \beta_1(UC_h) + \beta_2 \ln(d) + u \qquad (9)$$

where $\theta = \frac{\alpha}{\beta}$ and u is the error term. Moreover equation (9) is modified to accommodate dynamic effects during the modelling process including lagged house price effects, lags of other explanatory variables and an error correction term.

4.2 The Long-Run Relationship

Following a log-linear transformation of all the variables, a cointegrating relationship would be identified with whichever fundamentals possess a unit root. The long run relationship is expressed by Capozza et al. (2002) as:

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[7] This is so the authors can make use of data on construction costs.
[8] Note the term UC_h is explicitly defined in terms of constituent parameters by Cameron et al. (2006) and Muellbauer and Murphy (2008) but because other authors present alternative definitions we discuss the user cost variable later on.
[9] $\alpha = 1$

$$P_t^* = p(X_t) \quad (10)$$

where P^* is the log of real fundamental house price and X_t is the vector of exogenous determinants.

The actual members of the exogenous vector vary according to studies. For example, in Capozza et al. (2002) the set of long-run determinants includes population levels, real median income levels[10], the long-run (5 year) population growth rate[11], real construction costs and the user cost of housing. However in Muellbauer and Murphy (2008) and Cameron et al. (2006) the vector of long-run drivers contains real disposable (non-property) income, the sum of mortgage rates and stamp duty rates, the national credit conditions index and a term which interacts the mortgage rate with the credit conditions index. The latter may be a means of capturing the impact of credit rationing that may be induced by macroprudential policies as well as providing a better understanding of the impact of financial instability on housing markets.

4.3 Theoretical Basis for the Explanatory Variables

Here we briefly outline the theoretical justification for the inclusion of the aforementioned variables in the long-run relationship. Those already aware of the underlying issues could move on to Section 4.4.

Population Levels:

Population enters house price models via the housing demand equation where a rising number of household increases the price via excess demand (Meen, 2002; Poterba; 1984). In Cameron et al. (2006) population enters indirectly through the demographic effect in the dynamic equation. Specifically, the change in the proportion of 20 – 39 year olds in the working age population is expected to be positively correlated with house prices: as this proportion increases, the demand from first time buyers will also increase and with the assumption that supply constraints owing to land use regulation restrict new builds, house prices rise[12].

Capozza et al. (2002), who include this variable, are motivated by the differences in serial correlation and mean reversion that manifest between house price series belonging to different regions (cross-sections). One explanation for such differences arises from buyers' inability to determine the "true" value of a property; products are extremely heterogeneous and so agents typically rely on the informational content of previous transactions in the market to impute their true price. However if transaction volumes are low or if they are spatially and temporally distant, the information embedded in these sales is weak and agents are unable to set their reservation price easily (Quan and Quigley, 1991). In such cases, house price deviations from their fundamental levels are likely to persist for longer (lower mean reversion and higher serial correlation).

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[10] Both the population level and the real median income levels are included together because this also accounts for the size of the region (cross-section).
[11] This acts as a proxy for the expected growth premium.
[12] This demographic justification is also used by authors relying on alternative estimators such as Tsatsaronis and Zhu (2004), who use a VAR approach on a 17 industrialised country panel, suggest a broader measure of demographic effects: relative size of younger to older generations. However this ratio is excluded from their final model on the basis that its time series dynamics are captured by other variables included in their parsimonious model.

Thus Capozza et al. (2002) focus on the informational costs of house purchases and argue that these costs fall on average as the volume of transactions increases. Hence their rationale for the inclusion of population levels: by proxying the number of transactions, the population level captures the demand for housing and correspondingly the informational costs of house purchases.

We note that the impact of population or the size of the young cohort will be dependent on the scope of credit rationing in the mortgage market. To the extent that first time buyers are rationed, this may limit the effect of this variable, at least in the short run. This comment also applies to a number of the other variables discussed below.

Real Personal Disposable Income Levels

The relevance of income to house prices is apparent in Poterba (1984) where a simple separation of US states is made on the basis of volatility in house prices (high versus low). The house price to annual per capita income ratios are then computed for both groups. This reveals the effect of income on house prices: the least volatile house price regions have very stable price to income ratios as compared against the volatile regions. In other words, per capita income is likely to explain a substantial amount of long-term house prices but is less involved in generating short-run deviations.

The intuition behind the role of income and house prices is straightforward: it is the income of a household that determines the affordability of a potential house purchase. This income effect is formalised in Hott and Monnin (2008) who maximise a representative utility function subject to an income constraint both of which underpin the demand equation for housing. In conjunction with supply, the equilibrium (or fundamental house price) is then directly dependant on aggregate income. However, via this framework it is also possible to justify the use of per capita income as in the case of Case and Shiller (2003) or even real GDP as in the case of Collyns and Senhadji (2002) who argue that this captures aggregate income and population trends.

Miles and Pillonca (2008) examine house price behaviour in fourteen OECD economies over 10 years (1996 – 2006) and attempt to quantify the main drivers of house price changes. On average, approximately 45% of the change in house prices are due to increases in real GDP per capita[13] and for countries such as Ireland and Greece, the income contribution is as high as 108 and 81 percent respectively. The major stimulus from rising real incomes to property prices may also explain the generation of house price bubbles.

Real Construction Costs

Real construction costs are important determinants of house prices in that they underpin the supply function and thus help determine the price elasticity of supply. This in turn is a major determinant of the long-run price level (OECD (2010)). However, as discussed below, there is disagreement on the extent to which housing construction responds to current house price. In addition, non-priced factors such as regulation may explain why house prices in the short-run deviate from their long-run fundamental levels.

Real construction costs contribute to the marginal cost of housing production alongside land costs and normal profits to the builder (OECD 2010). Poterba (1984) assumes the housing construction industry is perfectly competitive and supply responds to the real cost of housing.

[13] Excludes Italy which has an anomalously low income effect.

However, Poterba (ibid) notes, according to Muth (1960) and Foley and Sidrauski (1971), there are divergent views on the stability of supply elasticities: the former assumes that long-run supply is perfectly elastic with respect to price in which case, in the long-run, the only determinant of house prices is real construction costs; the existing level of housing stock does not influence price. However in the Foley and Sidrauski (1971) model, the trade-off between the production of houses and other goods is not constant and so if the availability of individual inputs (such as skilled labour or timber) is restricted, the opportunity cost of building new houses increases and therefore so does the price of new builds.

Muellbauer and Murphy (2008) also note the divergent views on house price supply responsiveness and in particular discuss arguments by Mayer and Somerville (2000) who believe that house builders do not respond to the current price level but to the appreciation rate. They draw their conclusion for two reasons, firstly, house prices are a composite of their marginal costs of inputs which are mostly reproducible (e.g. bricks and cement). In this case, in the long-run, the price of housing depends on these factors and not on demand (similar to the Muth (1960) argument presented above). Moreover, since land (which is a factor input) is not reproducible, land appreciation will constitute much of the capital gain on dwelling (alongside limited appreciation of other reproducible inputs) so that residential construction predominantly depends on the price acceleration of land. The second reason is empirical: in reality the time series of housing construction is stationary whereas house price levels are not. In this sense the authors argue that there can be no long-run cointegrating relationship whereby new housing construction is explained by existing house price levels.

4.4 The User Cost of Housing

This variable is fundamental to most house price models in the literature in that it reflects the cost of home ownership. Meen (2002) defines the user cost as being equivalent to the marginal rate of substitution between housing services and an alternative composite bundle of goods. In this sense it can also be interpreted as the downward sloping demand curve for housing (van den Noord, 2005). More generally the OECD (2005) defines user cost as the expected cost of owning a house.

Whatever the interpretation of user cost, it is important to highlight that it is not directly observed; consumers do not explicitly encounter this variable when making allocative decisions. Hence Capozza et al. (2002) note that the user cost is a derived variable although we point out that the actual derivation of the time series uses a set of determinants which varies in the literature due to data availability or motivation of study. However according to Poterba (1984, 1992), McCarthy and Peach (2004) and Himmelberg et al. (2005) there are seven factors that should be included: (i) mortgage rates (ii) depreciation (iii) maintenance and repairs (iv) property taxes (v) risk premia (vi) capital gains and (vii) tax deductibility (on mortgage interest where applicable). We briefly describe the rationale for the inclusion of each of these variables before presenting a selection of user cost equations from the literature (which do not always include all seven factors):

(i) Mortgage Rates:

These are included in user costs because they represent the opportunity cost of funds for the buyer. This rationale also partly explains why some authors choose to use the yield on government securities instead of the mortgage rate: in theory the opportunity cost is the interest that could be earned on an alternative investment which could be equally proxied by government yields or mortgage rates provided the spread between them remains constant. In reality, factors such as credit market conditions are associated with changing spreads and so the distinction between mortgage rates and treasury yields may be important. For example, the OECD (2010) points out that increased competition amongst lenders and a change in their risk-assessment behaviour led to a recent decline in spreads in the OECD up to 2007. Moreover in some countries banks have actively cross-subsidised products in order to offer better mortgage rates.

Poterba (1984) notes that as the cost of home financing diverges away from the cost of borrowing the opportunity cost of housing equity changes and the user cost equation should be adjusted to include the loan to value ratio. This is because the latter essentially captures the risk borne by the homebuyer who is paying for a property that should be priced according to fundamentals, including the borrowing rate, but paying for the finance at the mortgage rate. The higher the loan to value ratio, the greater the user cost. On the other hand, as pointed out above, limits in loan to value ratios may also impact on the overall cost of owning a house, at least in the short run.

Poterba (ibid) makes a distinction between short term and long-term mortgage rates. When long-term rates increase, the future expected user cost increases and although there is no impact on user costs today, there will be an impact on current house prices since buyers assimilate the signal of higher future borrowing costs and reduce demand thereby reducing house prices. Hence Poterba (ibid) suggests that studies such as Hendershott (1980) which use long-term mortgage rates may have incorrectly measured the user cost. Gallin (2006) who constructs a composite mortgage rate which consists of the 30 year fixed rate and the one year variable rate on 30 year loans, both weighted by the proportion lent out in each category, may mitigate the short-term versus long-term issue to an extent. There are of course important cross country differences in mortgage markets that mean that either long or short rates may predominate.

OECD (2010) also makes a distinction between real and nominal interest rate effects. Whilst most studies use the real interest rate burden, there is a nominal effect that they may be ignoring. This arises because changes to nominal rates affect the repayment profile for the borrower; for most mortgage contracts, a rise in the nominal mortgage rate will mean repayments become front loaded so that so that debt servicing burdens are greater towards the start of the mortgage term. This means households are less able to borrow during the earlier years whereas if mortgage rates fall in nominal terms, households' budget constraints become more relaxed due to the ability to borrow and so demand for housing increases (Muellbauer and Murphy, 2008; Kearl, 1979). This may explain the divergences in the choice of mortgage rates in the literature: for example, Hendershott (1996) uses the T-Bill rate in real terms whereas Malpezzi (1999) uses the national mortgage rate in nominal terms. The short versus long rate distinction is also important when estimating house prices from the asset price perspective; this will be discussed later in the section on asset models of house prices.

Another important issue regarding interest rates is their role as a monetary instrument for the prevention of financial instability. Box 1 presents a selection of five user cost equations from the literature. In some cases the mortgage rate is used whilst in others the short term interest rate enters the user cost. From the financial stability perspective, monetary policymakers aiming to mitigate housing bubbles can effectively alter the short term rate with the view that this will be transmitted to mortgage rates and affect the user cost of housing accordingly.

However, as described above there will be a divergence in the estimated user costs based on short term rates versus mortgage rates if, for example, banks do not pass on base rate cuts to customers. In such cases the interest rate loses its potency and the user cost will not reflect the regulator's goal as has been observed recently where banks have not fully passed on interest rate cuts to customers. And where long rates determine the cost of mortgages, there is also the term structure relationship to bear in mind, whereby monetary policy changes may not affect the risk free long term rate if future short rate expectations are offsetting.

We noted above that the user cost is also related to the loan to value ratio. It can be argued that the LTV would be a better macroprudential instrument than the mortgage rate or short term rate because it would enable the specific manipulation of house prices without affecting the wider real economy unduly. During boom periods in property markets, regulators could dampen excess demand for housing by requiring mortgage lenders to impose lower loan to value ratios on marginal loans and conversely banks could respond to lower housing demand by raising the loan to value ratio.

(ii) Depreciation and (iii) Maintenance and Repairs:

OECD (2004) defines this as the recurrent costs associated with owning a home, arising from depreciation, maintenance and repairs. For their estimation on OECD data the authors assume a constant parameter value of 4%.

Although lack of data may necessitate the assumption of time invariant depreciation, Poterba's (1984) analysis shows this may be too much of a generalisation since apart from any other reason, depreciation costs should increase in line with population and real income per capita growth in order to ensure the ratio of housing stock to income remains is maintained across the economy.

(iii) Property Related Taxes

Van den Noord (2005) focuses on the Euro area to examine the impact of property tax regimes on the cyclical volatility of house prices since different tax regimes across member states will lead to different house price dynamics. Tax breaks to promote home ownership such as relief on interest payments cause the long-run level of house prices to increase. However tax subsidies are also likely to generate higher house price volatility through indirect means by amplifying housing market shocks such as changes in income, demography and building regulations.

Since income tax acts as an automatic stabiliser, property tax regimes may counteract this stabilisation effect. Van den Noord (ibid) notes that different tax regimes in monetary union members could thus generate different degrees of house price volatility and may explain why different union members display different growth rates and inflation rates.

Poterba (1984) notes that an increase in inflation which generates rises in nominal interest rates will both increase homeowners' mortgage repayment burdens and nominal capital gains. However in real terms, the user cost of homeownership decreases due to tax regimes which allow mortgage interest payments to be tax exempt. Under such frameworks home owners enjoy capital gains fully but only repay a fraction of the higher mortgage repayments and thus gain overall. Such considerations underpin the inclusion of property related taxes in the user cost equation.

This section on taxes is relevant since it shows that monetary or macroprudential policies are not the only way to limit house price bubbles. On the other hand it can be argued that given the long term nature of house purchase decisions, an appropriate fiscal framework may be best set for the long term rather than varied frequently, The role of changing property taxes in the US Savings and Loans crisis and the Swedish banking crisis are relevant in this regard.

(iv) Expected House Price Appreciation

In theory the expected user cost for potential investors should be influenced by their views on expected house price appreciation which thus influences the demand for housing. The OECD (2010) discusses two reasons as to why anticipated price movements may influence prices today: (1) speculative pressures (2) affordability.

Speculative buyers aim to benefit from expected house price appreciation when expected risk adjusted returns on homeownership exceed returns on other assets. However, agents that are not motivated by investment returns will also increase their demand for housing if they believe that future house price appreciation could price them out of the owner occupier market.

In the UK at least, affordability considerations are substantial for prospective buyers. The BSA (2007) which examined respondents' reasons for house purchases found that 28% of existing first time buyers and 68% of consumers considering purchasing first time viewed being priced out of the market as the main consequence of expected house price appreciation.

On the other hand, Miles and Pillonca (2008) are amongst those who suggest that house price expectations are backward looking; investors use the historic long-term house price growth rate alongside recent movements in house to form their expectations of future price movements. According to Shiller (2007) such psychological factors explain why fundamentals such as rents or construction costs alone are unable to explain house price movements. In reality, housing markets are not efficient; prices show momentum between successive periods as a manifestation of a behavioural feedback mechanism where repeated price appreciation serves to reinforce investors' beliefs that such trends will continue into the future.

Empirically, this momentum which is likely to generate higher serial correlation and slow mean reversion is modelled by Capozza et al (2002). They cite Case and Shiller (1988, 1989) and Shiller (1990) who suggest serial correlation in house prices arises from backward looking expectations.

Case and Shiller (1988) surveyed buyers in a control market and a "boom" market and found that boom market buyers believed expected house price appreciation would be higher than in the control market where prices had not risen by much in the past. Accordingly, behavioural reasons may explain why serial correlation is stronger in buoyant markets than in situations where the housing market is exposed to lower income growth.

Capozza et al. (ibid) accommodate such effects by augmenting the long-run relationship with dynamic serial correlation and mean reversion terms which are allowed to vary spatially and temporally. This allows differences in behavioural responses to house prices across regions and through the economics cycle to be captured. The mean reversion term accounts for the impact of psychological factors on the long-run price level.

Whether anticipated house price movements are modelled explicitly or as part of the user cost equation, most investigators rely on survey data for house price expectations or proxy this with the current inflation rate. Although the latter approach is common, Capozza et al. (ibid) note that it does not accommodate regional variation in expected house price appreciation which would impact on user costs accordingly.

The role of serial correlation in house price movements and underlying expectational shifts helps to explain why housing booms are hard to stop once underway. The UK experience of raising interest rates in the late 1980s is relevant in this regard. It is only when a major shock to confidence occurs that the bubble ceases to exist, and at that point a major collapse is likely, threatening financial stability. The underlying lesson may be that monetary or macroprudential polices are best deployed early on in the housing cycle, before there are entrenched speculative elements. Later on such policies risk to be ineffective, although arguably an effective LTV policy may be more effective than interest rates in this regard.

(v) Risk Premium

Although Poterba (1984) does not incorporate investors’ risk preferences during the derivation of user cost, he does recognise that a complete model of asset market equilibrium would include the impact of risk tolerance on investors’ demand for housing as an asset.

In Hott and Monin (2008) investors’ risk premia are assumed to be constant and are thus combined with maintenance costs and property taxes as an aggregated user cost input. However Sinai and Souleles (2005) suggest that risk premia can vary and can take both positive and negative values. Risk arises from the decision to own and occupy versus the renting of housing services; whereas capital gains or losses arising from ownership only materialise at the point of sale, changes in rental charges can occur in each period. The differential in risk declines as the time horizon of agents is extended so that if occupation of a given property occurs for long enough the risk premium can become negative.

Having discussed the components of user cost and their theoretical underpinnings, in the box below we present a selection of user cost equations in the literature which vary according to the motivation of the study.

We next turn to describing some short run specifications in brief. These recognise that house prices deviate from their long-run fundamental values and attempt to specify an empirical relationship to track these short-term dynamics.

Box1: User Cost (UC) Equations in the Literature

Poterba (1984):

UC = [after tax depreciation + maintenance + (1 – property tax rate)(mortgage rate + opportunity cost of housing equity) – inflation rate]

Capozza et al. (2002):

UC = (mortgage rate + property tax rate)(1 – income tax rate) – inflation rate

Gallin (2006):

UC = price[(mortgage rate + property tax rate)(1 – income tax) + maintenance and depreciation – expected capital gains}

Meen (2002):

UC = price[(market interest rate + depreciation rate – inflation rate – expected house price appreciation)(1 – income tax rate)]

OECD (2005):

UC = (mortgage rate adjusted for tax relief + property tax rate + maintenance and depreciation and risk premium – expected capital gains)

4.5 Short-Run Dynamics:

Cutler et al. (1991) provide a rationale for the inclusion of dynamic terms in house price models. They examine a host of asset types, including real estate, and find that asset price behaviour is typically displays 3 characteristics:

(1) positive serial correlation in the short-term
(2) negative serial correlation in the long-term
(3) the deviations of asset prices from their long-run fundamental values contain predictive information

They suggest these characteristics arise due to speculative motives of market participants and in combination they justify the inclusion of dynamic terms alongside fundamental house price determinants; the informational content of such dynamic terms will have predictive value. Cecchetti et al (2002) specifically delve into the properties of serial correlation and mean reversion terms of house prices. Whilst Cutler et al. (ibid) generalised the dynamic terms into descriptors of asset prices in general, Cecchetti et al. (ibid) put forward specific theoretical reasons as to why these terms should manifest in house price series. Informational reasons, transaction costs and supply side factors can all be used to explain serial correlation and mean reversion and since these factors are likely to differ across regions and time, it is also likely that the serial correlation and mean reversion terms will differ across cross sections.

To test the above proposition, Cecchetti et al. (ibid) augment the long-run relationship (equation 10) with dynamic terms according to:

$$\Delta P_t = \alpha \Delta P_{t-1} + \beta (P_t^* - P_{t-1}) + \gamma \Delta P_t^* \quad (11)$$

where

α is the serial correlation coefficient
β is the mean reversion coefficient and $0 < \beta < 1$
γ is the immediate partial adjustment to the fundamental value

In general as α increases, the amplitude and persistence of the cycle will increase whilst as β increases the frequency and the amplitude of the cycle will increase.

The estimators in the literature do not always take the exact specification highlighted above. For example, Terrones and Otrok (2004) take a dynamic panel approach based on the GMM estimator which also contains the lagged dependant variable. Like Cecchetti et al. (ibid) they point out that if the autocorrelation coefficient (α) exceeds a value of one, house price growth will be explosive.

While authors such as Gallin (2006) focus on the long-run behaviour of house prices, others specify dynamics by using autoregressive distributed lag models in error correction form (Meen, 2002). Several structural specifications have also been used in the literature such as the VAR (Hott and Monin, 2008; Sutton, 2002) and the SVAR (Tsatsaronis and Zhu, 2004) since such studies focus on the interdependencies of house prices and their determinants such as term spreads, house price inflation, GDP growth and the growth rate of private sector credit.

4.6 The Asset Pricing Approach: No Arbitrage Equilibrium

In this section we briefly outline an alternative house price modelling approach which has been used in the literature. Poterba (1984) proposed the no arbitrage approach to house price valuation which requires that the one period return from owning a house must equate to the return that could be obtained by holding an alternative asset[14].

In an extension to this approach housing service users can be thought of as investors who face a choice between renting and owning a property. In this case they will equate the marginal value of renting a house to the cost of owning a house which is the user cost of housing. Van den Noord (2005) represents this equilibrium as:

$$R(H) = UC \bullet P_H \quad (12)$$

where $R(H)$ is the marginal value of rental services per period on an owned and occupied property, UC is the user cost of housing[15] and P_H is the price of owner occupied housing.

[14] Poterba (1984) interprets this as the short-term interest rate. He also assumes risk does not feature in the investor's decision.
[15] Van den Noord (2005) defines this explicitly.

A similar approach has been used by OECD (2005) where equation 12 is re-expressed in terms of the price to rent ratio in order to determine the degree of overvaluation of OECD house prices:

$$\frac{P_H}{R(H)} = \frac{1}{UC} \quad (13)$$

Equation 13 translates house price valuation to asset market models where $\frac{P_H}{R(H)}$ is analogous to the price-to-dividend ratio. If the price to rent ratio is high, investors will gain by renting housing services and the subsequent drop in demand for owner occupancy will restore the equilibrium relationship.

However there are problems associated with this interpretation of equation 13. Firstly the OECD (ibid) results suggest the price to rent ratio is non-stationary. Secondly, the user cost of housing is itself not static and may be subject to shifts in institutional factors such as mortgage market innovations which alter the cost of mortgage finance. Moreover, expectations of future house price appreciation are driven to an extent by behavioural factors and thus extremely hard to model (Miles and Pillonca, 2010). As discussed in the sections above, backward looking expectations which give rise to serial correlation in house prices will impact on the user cost accordingly.

Despite the caveats mentioned above, the asset model approach can be used to indicate general under or overvaluation of house prices. In theory, it can also be used to assess housing market efficiency (Meen, 2002) since the no arbitrage condition should ensure that equation 13 holds. However the existence of serial correlation in house prices suggests the market is inefficient since persistent excess returns become possible. One potential explanation for the inefficiency may be the presence of search and transaction costs which restrict buyers to specific geographical regions. This in turn means transaction volumes are lower than they would be in a more efficient market and so buyers have restricted access to information that could be used to compute fair house price valuations (Capozza et al., 2002). Another problem may be the planning regulations which restrict housing supply. Consequently, buyers have limited scope to exploit arbitrage opportunities and in this sense the asset pricing approach may be flawed.

4.7 Key factors omitted from most extant studies

Institutional factors relating to mortgage markets are typically not taken into account in house price estimates. In fact, many mortgage market innovations that have altered the terms and availability of credit have emerged in OECD financial markets over the past 30 years (OECD, 2005). This financial deregulation has not only increased competition, it has also led to the creation of new products such as buy to let mortgages, interest only loans and offset mortgages which allow borrowers to offset their savings against the mortgage balance.

As a result of such innovations, the availability of mortgage credit has risen dramatically in Europe and the US. Miles and Pillonca (2008) note that although the mortgage debt to GDP ratio varies across Europe (exceeding 70% in countries like the UK and Denmark), the stock of mortgage debt has risen in all cases. Consequently house buyers have seen a relaxation in their borrowing constraints and this has fed back positively to house prices.

Nevertheless, as this section has shown, few house price models have taken these fundamental changes into account. One possible way of doing so are to restrict the sample so that it only contains post liberalisation observations. However, this has the problem that there is likely to be a long period of adjustment of balance sheets to liberalisation that may well distort estimates. Furthermore, the period may be too short to adequately capture long run relationships in the housing market. An alternative is to include a pre liberalisation period in the sample and allow coefficients to vary by use of leveraged dummies. We employ both approaches in our estimation below.

Mortgage spreads (loan less deposit rates) are also typically not included in house price equations, whereas these could be relevant to the impact of capital requirements on interest rates, as in Barrell et al (2009) and have important consequences for household incomes as well as for house price dynamics. We include such a term in our quarterly equation for Sweden below. Equally, despite recognition that housing is part of the asset portfolio of the household sector, most studies do not take the logical step of including household gross financial wealth, as a substitute asset, a rise in whose value would lead naturally to rising demand for housing for portfolio balance reasons.

An additional question raised by financial liberalisation is whether the stock of mortgages is appropriately included in house price equations. This was traditionally the case in pre liberalisation estimates in countries such as the UK (e.g. Hendry 1984) but was judged by authors such as Muellbauer and Murphy (1997) to be inappropriate in a post liberalisation sample, since the stock of lending is endogenous to the determination of house prices (this is consistent with the Granger causality results from Barrell et al (2011) cited above). On the other hand, if there remains a degree of rationing for some participants in the housing market, then the mortgage stock could have a role to play, and all the more if macroprudential policies have an effect of reintroducing forms of credit rationing. And indeed along these lines Miles and Pillonca (2008) do argue that the existing mortgage stock should also be included. We test this also in our work below.

A further exception to the typical omission of these effects is the model of Muellbauer and Murphy (2008) who note that deregulation of mortgage markets has implications for monetary policy transmission and business cycles and that these changes are exerted via the interaction of house prices, housing finance and the real economy. Mortgage credit availability drives house prices and thus influences consumption and the supply of new housing stock. Moreover, if the housing wealth effect is negligible then the credit channel becomes crucial for explaining why consumption rises in response to house price appreciation: deregulation of mortgage markets means more homeowners can withdraw equity against a rise in their property values.

In recognition of the above, Muellbauer and Murphy (ibid) include a credit conditions index which they introduce both alone and as an interaction term with the mortgage rate. The credit conditions index is constructed using 10 consumer credit and mortgage market indicators as described in Fernandez-Corugedo and Muellbauer (2006). It is included so as to capture shifts in the credit supply function faced by households in the post-1980s era. The authors note that by omitting this variable, previous house price models in the literature (which typically utilise pre-1980s data) suffer from omitted variable bias.

Unemployment may impact on house prices via demand and also if it entails widespread defaults and consequent “fire sales” but is typically not included in house price equations, as may banking crises per se, which give rise to uncertainty and credit rationing that other variables may not adequately capture. Certain supply aspects of housing are also typically omitted. Many studies do not even include housing investment or the value of the housing stock as an influence on house prices. But beyond this there is the influence of planning regulations in restricting supply, nationally and/or in local areas subject to high demand. And there is the potential influence of a regulated rental market for housing.

5 Estimation of house price equations for an OECD panel and for Sweden

5.1 Specification and data

In the light of the above literature survey and limited experience of macroprudential tool as applied to housing markets, we sought first to estimate panel equations for house prices in OECD countries, with a view to assessing how macroprudential tools could usefully operate, as well as whether suitable international rules could be devised. Given the extensive availability of cross-country data from the NiGEM database,[16] we have scope to investigate the common patterns of property price movements, while at the same time controlling for heterogeneity across countries or at different stages of real estate cycles. This in turn casts light on the relevance of earlier work cited in Section 1. The panel specifications (with details below) are the appropriate tool for this purpose. Moreover, from an econometric perspective, a panel approach gives more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency (Baltagi, 2005, p. 5).

A first table shows the data sample we are able to use, which for most countries is back to the 1970s. We hence include periods when there has been liberalisation as well as structural regulation in the housing market. This can be justified by the need for cointegration equations to have as long a data period as possible. But it will also be of interest if we can capture the differences in behaviour between liberalised and non-liberalised periods, since the introduction of macroprudential instruments will lead to a reintroduction of some form of credit rationing as was typical of the pre-liberalisation period. Note that we use annual data for the cross country panel work, We contend that annual data ensures that dynamics can be simple and comparable, while it facilitates a focus on the long-run properties of the data.

Table 2 shows the standard panel unit root tests for the main variables. They use the Im-Pesaran-Shin approach to calculation. It can be seen that the bulk of the variables, being trended, are I(1), at least at the 1% level thus justifying an error correction model based approach to estimation. In Eq. (5) the change in the dependent variable, DY (i.e. changes in real residential property prices), Accordingly, house prices were regressed on contemporaneous changes in explanatory variables, and lagged dependent and explanatory variables (both in levels) as well. This error-correction specification is able to deal with non-stationarity in the data (as mentioned above), and at the same time offers further tests of the theory by distinguishing short- and long-run influences on commercial property prices. The significance of the coefficients for lagged non-stationary variables (in levels) and their magnitude reveal the long-term relationship among those variables.

Our modelling started from the work cited above with a basic equation where we include real house prices, real personal disposable income and the long term real interest rate (proxying the user cost). We use this as a foundation for applying further tests of extra variables that could be added.

As a first step, we start with the pooled regression that treats all countries as equally important, while the fixed effects take account of heterogeneity. This regression is able to

[16] Note that the population data in NiGEM are interpolated annual data from the UN Demographic database (in our case we use the original annual data).

give us a preliminary view of whether the theoretical hypotheses set out above are validated by the data. Meantime, the result also serves as a benchmark for the follow-up discussion on distinctive characteristics of real estate cycles for different markets of interest. We then proceed with a number of sub-sample panel regressions, in which each panel only consists of a particular group of countries (with similar market arrangements).

Hence, we first estimate for all 18 OECD countries but also for two divisions of that group. The first is between the large and small countries, with the large countries being the G-7 and the small countries the remainder. Then we have the division between the Anglo Saxon and bank-dominated countries, where the former are the UK, US, Ireland, Australia and Canada and the latter are the remainder. These breakdown analyses offer deeper insights by allowing for richer heterogeneity, e.g. distinctive economic determinants in each sub-sample (compared to the pooled regression). The combination of the pooled regression and the sub-sample panel regressions reveal elements of both commonality and uniqueness in commercial property cycles in those 17 countries.

To confirm the existence of the long-term relationship, we also implement the panel cointegration test proposed by Kao (1999) among those variables with significant lagged level terms in a simple levels equation (i.e. the first step of an Engle and Granger (1987) two-step estimation).

5.2 Results for the full panel sample

Table 3 shows the basic results for the full sample from 1970-2009, with real long rates and real personal disposable income entering the equation. It can be seen from the Kao tests that the long run of all the equations cointegrate except for the G-7. This may link to the group being relatively small and non-homogeneous given the inclusion of both bank and market dominated countries. As regards the results, in the short run we find a strong income effect with an elasticity of 0.8 for all countries, larger in the G-7 and Anglo Saxon countries and lower in the small and bank dominated ones. The short run real rate effect is negative as expected, and significant for all countries, small countries and the Anglo Saxon ones, with a similar coefficient magnitude. A 1 percentage point rise in long real rates leads to a 0.5% fall in house prices in the short run.

A very consistent effect is the short run serial correlation term, which is highly significant, and around 0.5 in each case. In other words, a rise of 10% in house prices one year gives rise to a 5% rise next year independent of the other coefficients in the equation.

Turning to the long run results, we have a highly significant error correction term in each case of around 0.08, which means a slow adjustment to the long run fundamentals, around 12 years in fact. Their significance is supportive of cointegration (see Pesaran and Shin, 1995) as is confirmed by the Kao tests for most of the equations. Then the long run income elasticity is somewhat below the theoretical level of one, around 0.7-0.8 in most cases. The long run interest rate effect is significant except for the G-7, with a long run elasticity of around 4, i.e. the long run impact of a one percentage point rise in long real rates is to reduce the level of real house prices by 4%. These contrast to some degree with the results of Terrones and Otrok (2004) with a similar panel, who found an income elasticity of 1.1 and an interest rate elasticity of –1.0. Country studies cited in OECD (2005) are much closer to ours, however.

We undertook F tests on the pooling assumptions in the groupings and found that for both categories, the divisions were preferred to the "all" sample. This was more the case for the G7/small breakdown than for the Anglo-Saxon/banking split. (In the former poling was rejected at 99% whereas for the latter it was only rejected at 95%). Accordingly, we consider closely the G7 and small country results, with particular focus on the latter as being relevant for Sweden.

Table 4 shows the variants on these basic results, which we consider highly satisfactory in general terms. We first sought to include a cubes lag in house price growth. This was suggested originally by Hendry (1984) as a proxy for "frenzy" when a large rise in house prices gives rise to a further boost, suggestive of bubble formation. The expected coefficient is positive. In fact we find only a significant negative coefficient for all countries, the G7 and for the bank dominated ones. This implies rather a form of mean reversion in growth. It may be that using annual data gives rise to periods too long for "frenzies" to be detectable, whereas a shorter quarterly frequency might have captured it.

The second variant is with log stock of real mortgage debt included. We note in this context that there is a theoretical argument, which has been borne out by much empirical work, that mortgage debt should not be causal for house prices in a liberalised financial system. This is because it accommodates to house prices, when it is freely available. Such a surmise was partly confirmed, for example, by Granger causality tests in Barrell et al (2010) between personal debt and house prices, which showed causality from credit to property prices only in Belgium, Canada and Finland from a group of 14 OECD countries, although some causality was also found for Sweden in the pre-1995 period. At least, we considered it essential to instrument the difference of credit, so that results were not affected by simultaneity with house prices. The instruments were the lagged difference of house prices, income and interest rates.

The results were that there was indeed a significant impact of credit on house prices in a number of subgroups, albeit generally only in the short term, with a quite consistent elasticity of around 0.15. Comparison with Davis and Zhu (2010)'s estimates for commercial property prices with similar panels showed a much higher coefficient of around 0.8. In commercial property the incidence of rationing is likely to be much greater. As noted, there is only a long run effect in the small countries, with a long run elasticity of around 0.4.

An objection to such results is that the sample, typically from 1970-2009, includes periods of both financial repression and financial liberalisation. We used dates from OECD (2000) to fix the time of financial liberalisation, As in Barrell and Davis (2007), we then defined dummies distributed from 1.0 prior to liberalisation to 0.0 five years after, with the transition being in the form of an ogive imposed to conserve degrees of freedom. The coefficients on the differences in debt and lagged debt were then leveraged by these dummies to give scope for the parameter to change gradually with liberalisation. Our result for the G7 we consider unsatisfactory due to outliers and should be disregarded. However, the result for the small countries is of interest, suggesting as it does that the short run elasticity for debt changed from 0.44 before liberalisation to 0.09 thereafter. This is in line with the hypothesis of a fall in the impact of mortgage lending with liberalisation, while leaving an ongoing small positive effect. The small countries of course include Sweden. The results for all countries, the Anglo Saxon and bank dominated are unchanged by the dummy, however.

The implication of this result for the mortgage stock is that a macroprudential policy that affects the mortgage stock will have an additional effect on house prices over and above the interest rate/user cost change that may underlie it. Hence the effect of macroprudential policy will be greater than if the mortgage stock variable had been absent.

The third variant was using a demographic variable, namely the proportion of 20-39s in the population. In countries such as the UK this is considered to be the prime age group for property purchase. However, it is acknowledged that this may not hold in other countries such as Germany where renting is more common at this age, and house purchase may be delayed till later in the life cycle. Possibly consistent with this, we only obtain a significant result for the "Anglo Saxon" countries where owner occupation is high and also mortgages are freely available for most of the sample. There is a short run elasticity of 1 between the size of this age group and the house price, and in the long run the effect is around 1 also.

We then sought in two ways to allow for supply in the equation, firstly by including a flow variable which is the ratio of housing investment to GDP, then by adding a stock variable, the ratio of the estimated housing stock to GDP. The latter is estimated on the basis of a perpetual inventory model with a deprecation rate based on a life of 75 years, and the initial year's investment/GDP ratio. Hence it may well be inaccurate. That said, there is evidence of supply effects for the small countries, and to some extent in the Anglo Saxon ones, but not elsewhere. The effect in the small countries is as would be expected, with a rise in the supply leading to lower house prices. On the other hand, the Anglo Saxon result is a positive one, suggesting that housing investment tends to accompany booms in house prices.

We tried two dummy variables directly in the equations. First we assessed whether financial liberalisation has had a direct effect on house price growth, with systematically lower growth before liberalisation. Then, we tested whether banking crises had a marked effect, over and above any effect from the changes in income and interest rates. As can be seen in Table 4, the liberalisation dummy (as defined above) had no significant impact, while banking crises (with periods defined as in Caprio and Klingebiel (2003)) were highly significant and negative in all cases. We can hypothesise that crises impact via uncertainty and credit rationing effects that the existing variables are unable to capture. For the most part, the crisis variable complements but does not supersede the other variables in the equation. Crisis impacts are worse in small countries than the G-7, and in bank dominated countries than in market based. In the latter, there are in most cases alternative sources of finance to banks (e.g. securitisation – except in the latest episode) which may mitigate the impact of bank failures on the housing market. There have tended to be a greater proportion of systemic crises in the smaller than the larger countries also.

Does unemployment impact on house prices, via greater uncertainty and incidence of default? The Table 4 shows that this is the case in most of the country groups for the difference of unemployment, but not the levels. A 1% rise in the rate of unemployment reduces house prices by around 1% in the first year. It is notable that the largest effect is in the Anglo Saxon countries where unemployment is typically more volatile and protections against default less.

Finally in this section we tested for an effect of gross financial wealth on house prices. The idea is a portfolio balance one, whereby high financial wealth might lead to shifts in allocation to real assets, thus boosting house prices. The empirical results suggest that this is an effect worth considering, with significant results for the difference in all countries, the small and bank dominated ones. A 1% rise in real financial wealth boosts house prices by around 0.1-0.15%. There is also a significant long run effect in the G7 countries only, where the elasticity is around 0.7. A counter argument to including wealth is that the relevant information should be captured by income and interest rates.

5.3 Results for the post liberalisation period

A feature of the above results is that we have admittedly included both periods of financial liberalisation as well as non liberalisation. Accordingly, we may be vulnerable to shifts in coefficients within the sample. On the other hand, we do benefit from a long data period which includes several cycles and hence should well capture the long run properties of the data. Accordingly, we retain the above as our main set of results, but test in two ways for possible biases. First, we shortened the sample for each country to begin with financial liberalisation. Second, we sought in the manner of Barrell and Davis (2007) to do generalised leveraging of coefficients, to see whether the partial results for debt cited above generalise to some of the other terms. We comment on these results relatively briefly, to mainly highlight contrasts with the main results in Tables 3 and 4.

For the liberalisation period, the methodology was to multiply the dependent variable by a dummy which is 1 for all periods after liberalisation. This reduces the sample from 618 to 413 in the all countries case, for example. The most noteworthy feature is that we "lose" the long run income effect in this shorter period, and it becomes insignificant. This may be due to the protracted adjustment period after financial liberalisation, although a further experiment with an even shorter period 5 years after liberalisation also produces counter intuitive results (a negative income effect for "all countries" for example). We consider this result to mean this is an unsatisfactory result overall. Nevertheless, some differences with the full panel remain noteworthy. As shown in Table 5, the short run income effect is lower and the interest rate effect is consistently higher. There is more serial correlation in house prices when the later period is considered alone. And the adjustment to the long run equilibrium is generally slower, although the long run income effect is higher. This suggests a more volatile period when house prices can deviate further from equilibrium and fundamentals, albeit strongly driven by real long term interest rates.

As regards the variants (Table 6), we do not find a significant cubic term in the later period. On the other hand, the debt effect remains in the short run in all cases, with a comparable coefficient to the full period, and a negative long run effect in the Anglo Saxon countries, perhaps caused by the recent falls in prices in 2007-9. Demography continues to be significant for the Anglo Saxon countries too. We find long run effects for the housing stock in the G7 and Anglo Saxon countries which are negative in line with theory, but no investment effects. Crises remain powerful determinants of house prices. Most of these of course occurred after liberalisation in any case. We now find a long run as well as a short run effect of unemployment in all countries and the bank dominated ones. And wealth is a consistent determinant of house prices in the short run across the country groups.

5.4 Applying leveraged coefficients for the pre liberalisation period

Although the above-cited results from Tables 5 and 6 add to knowledge, they remain unsatisfactory due to the long run income effect being zero. We accordingly go on to comment on the full sample regressions with the pre-liberalisation dummies (i.e. one for unliberalised phasing to zero five years after liberalisation). So for example in Table 7, the variables labelled X*Lib show the absolute difference in the coefficient before liberalisation compared with after it. If all of these coefficients are insignificant, the equation is stable between the two regimes. If on the other hand there are some significant coefficients, it is indicative of structural change.

A first point to note from Table 7 is that the unleveraged coefficients are comparable to the basic estimates in Table 3 over the same time period, which is a positive sign. As in Table 3, all of the coefficients are significant except for the long run effect of the long rate for the G7. As regards the leveraged coefficients, we can see that the short run is much more affected than the long run. We have evidence of a much lesser response to income growth since liberalisation for example (positive leveraged dummies are significant for all groups except the small and bank dominated). The short run interest rate effect was absent before liberalisation for the Anglo Saxon and G7 groups. And the serial correlation "bubble building" effect is much greater in the G7, Anglo Saxon and All countries groups since liberalisation (and also at 90% for the bank dominated countries). Equally, the adjustment coefficient suggests that there was slower adjustment to the long run before liberalisation, apparently in contrast to the differences between Tables 3 and 5. There are in contrast no significant coefficients for the long run, except that prior to liberalisation the small countries have a smaller long run interest rate coefficient. The income term is totally unchanged.

Looking at Table 8 where we leverage the variants, there are no significant effects or differences for the cube term. Results for debt are comparable to those in Table 4, except that of course we are also permitting other terms to vary as well. The key result is again that for the small countries, where the debt effect in the short run was much greater before than after liberalisation. There is some evidence for a demographic effect in the G7 well as the Anglo Saxon countries in the post liberalisation period, while supply effects only appear now in the G7. There is a positive crisis effect in the Anglo Saxon countries, which we attribute to a single observation – virtually all OECD crises were after liberalisation. As regards unemployment, it appears to have impacted on house prices mainly before liberalisation in the G7 and Anglo Saxon countries, whereas for the smaller countries (and all countries) it is consistent across the sample. Finally, the financial wealth effect is apparent across the whole sample in first difference form only. Noteworthy patterns from Table 8 are again that there are virtually no changes to the long run specifications, only some amendments to the short run results.

Reflecting on the impact of macroprudential instruments, it seems likely that LTV limits could be incorporated as feeding through the discount factor, as they require further saving to take on the mortgage (the interest rate term) also affecting the volume of credit (the stock of mortgages would decelerate). Capital ratio increases could similarly be an interest rate effect although perhaps a better index would be the spread between deposit and loan rates – a form of risk premium.

5.5 Quarterly estimates for Sweden

Against the background of the panel estimation, we estimated an equation for Sweden using quarterly data for the model simulations from 1970-2009.[17] We include the key variables which are significant in the small countries panel, but also can include the spread between the deposit and lending rate, unlike in the cross country panel data where this variable is not available for most countries over a sufficiently long sample period. As noted, this variable can capture the impact of higher capital requirements for mortgage lending, affecting as it does the deposit rate and also the lending rate.

Four versions are shown in Table 9. The first has long run income homogeneity not imposed, the second has that restriction and the third includes estimates for the additional variable bank spreads between household loan and household deposit rates. The fourth imposes the same coefficient on spreads and long rates, as is required in the NiGEM model as discussed below.

As can be seen in Table 9, the equations are all well behaved statistically, with no autocorrelation or non-normality despite the differing regimes during estimation. There is

[17] Source: BIS; quarterly data before 1986 were annual data interpolated.

however some evidence of heteroskedasticity, which may relate to the greater volatility of house prices in the more recent period. The only difference between pre and post liberalisation coefficients that was significant was the difference of income term, which is much larger prior to liberalisation. Other significant short run terms are on wealth and liabilities, there is also a large serial correlation term (lagged difference of house prices) of around 0.5. There is no short run interest rate effect. The freely estimated long run income elasticity is around 1.6, while there is also a significant long run interest rate and spread effect. The freely estimated spread effect is larger than the interest rate effect.

It is the final column equation that is incorporated in our NiGEM simulations. It allows macroprudential policy to operate in three ways, via the long term real interest rate, via the spread (which affects household incomes as well as the cost of credit) and via the mortgage stock. On the other hand we note that this specification is not very "dynamic" in the sense that although there is a major serial correlation coefficient, the shocks feed through slowly given the low income-difference term as well as the slow adjustment to the long run.

6 Interactions of macroprudential policies with monetary policy, and simulations with the NiGEM model

In a final section of our work, we first review overall comments and the limited amount of technical work on macroprudential and monetary policies. We then go on to carry out simulations on the Swedish component of the NiGEM model, comparing the effect of housing market related macroprudential policy with that of monetary policy and more general macroprudential instruments. We consider the impacts on house prices, real activity and also credit formation of the various shocks that can be imposed.

6.1 Overall comments

Looking first at the interaction of macroprudential with monetary policy, Barrell et al (2010a and b) cited above have shown that the overall country adjustment in prudential policy to reduce crisis probabilities depends partly on macroeconomic volatility. So one argument one can make is that if monetary policy can reduce house price bubbles and imbalances in the current account, it impacts on macroprudential adjustment.

On the other hand, extant comments suggest it is more doubtful that macroprudential regulation will significantly affect the macro economy and hence the demands on monetary policy. This is based not only on NIESR calculations but also the Basel calculations that were made in FSB (2010). According to simulations with macroeconomic models in various countries, 1% more capital and liquidity seems to take around 0.1% off GDP which is not huge and only 0.03% if all countries moved together. So in other words, the effect of regulatory tightening on the macro economy are small so long as the tightening is gradual which is a point relevant to monetary policy.

As the BIS point out in their recent Annual Report (2010), there are some benefits to monetary policy of a more active macroprudential policy. Less financial crises imply less economic fluctuation. If crisis risk can be reduced, interest rates are less likely to become ineffective due to financial distress, and also there will be less need to cut interest rates for financial stability in the downturn with possible inflation risks. Conflict between monetary and macroprudential seems is possible mainly well in advance of a crisis, since inflation may be subdued but there may be pressures on asset markets. Then one might wish to pursue a tight macroprudential policy and an easy monetary policy. Once inflationary pressures also emerge both macroprudential and monetary policies should be tightened, but this may be too late to prevent a crisis. After a crisis, both policies should be loosened, although as noted there may be inflation risk from holding monetary policy too loose for too long.

6.2 Extant technical work

We note there are rather few papers that have sought to look at monetary and macroprudential policy together. These are typically in stylised calibrated models rather than estimated ones. And a comment from one such paper is relevant "within a standard macroeconomic framework, it is very difficult to derive a satisfactory way of modelling macroprudential objectives" (Angelini et al 2010).

For example in Kannan et al (2009) they use the standard New Keynesian model as for example in Gali (2009) and add, first, a choice on the part of households how much to invest in housing as well as how much to consume, second, a distinction between borrowers and lenders, and third, the lending rate is modelled as a mark-up over the policy rate dependent on LTV ratios, the mark-up over funding rates, and in some simulations a macroprudential instrument. So for example a rise in house prices leads to a fall in LTVs and hence in mortgage rates even if the policy rate does not change. Market competition can also affect the mark-up. Hence, there can be endogenous house price and investment booms.

The general results are that strong monetary reactions to such financial accelerator effects that drive credit and asset price growth can improve macroeconomic stability compared with a simple Taylor rule, while a macroprudential tool against credit cycles, applied in a discretionary manner, could also stabilise the economy. Such rules would entail additional capital or provisioning when credit grows in excess of a certain rate. They note however that because it is not always straightforward to identify the cause of house price movements, a rigid rule could increase macroeconomic instability. In particular, whereas a relaxation in lending standards (financial shock) can be well catered for by rules, this is not the case for an increase in productivity (real shock). In the latter case resisting rises in credit would be inappropriate and cause undershooting of inflation targets.

Angelini et al (2010), use a similar dynamic general equilibrium model of the Euro Area to address the issue of appropriate macroprudential tools and rules and their interaction with monetary policy. Their extensions of the DSGE model are for a banking sector with capital, loans to households and firms and deposits from households. Interest rates are sticky owing to banks' market power. There are risk sensitive capital requirements generating procyclicality and heterogeneous creditworthiness of agents. The macroprudential policies are capital requirements and loan to value ratios, where the latter gives rise to credit rationing for households given the value of the housing stock. The former affects both firms and households, by contrast.

They find that macroeconomic volatility can be reduced by active management of macroprudential instruments in cooperation with monetary policy but the benefits are not large. When there is a technology shock, macroprudential policy should focus on output and not loans or equity prices, for the capital based rule, but loans is preferred in the case of the LTV. When there is a credit crunch shock, that destroys bank capital, both policies should focus on loan growth. Overall, the capital policy is more effective at reducing volatility of output growth, and LTV at reducing variance of the loan/GDP ratio, suggesting there is in their model a trade-off of stabilising economic activity and financial stability.

As regards the coordination issue, both policies operate partly by affecting the interest rate on loans. In a cooperative game between policymakers output variability is reduced. But if there is a non-cooperative Nash equilibrium, then substantial coordination problems emerge. In other words, there is a risk of coordination failure if suitable coordinating mechanisms are not devised.

Finally Angeloni and Faia (2009), give a DSGE model with a competitive banking sector and the possibility of bank runs, where the monetary policy is allowed to react to asset prices and leverage as well as inflation and output, and capital requirements can be pro or anti cyclical. There is a need for mildly counter cyclical capital requirements and a monetary policy that reacts to asset prices or leverage as well as inflation.

As noted by Angelini et al (2010) a difficulty of all these is that systemic risk cannot readily be modelled, although stabilising the loans/GDP ratio and GDP growth around their steady state values could be justified by definitions of macroprudential aims such as those of the Bank of England "the stable provision of financial intermediation services to the wider economy, avoiding the boom and bust cycle in the provision of credit". Of course, systemic risk will heighten economic volatility, and the loans/GDP ratio may be one factor underlying systemic risk (although we argue in Section 2 that it is not the most important one).

6.3 NiGEM simulations

We turn now to simulations using the NiGEM model for Sweden. The NiGEM model is presented in Appendix 1. In sum, it contains elements of demand, including consumption, and a supply side with a production function that is driven by technology and the user cost of capital and is the main determinant of the development of the economy in the longer term. Financial markets are forward looking, as are factor markets. i.e. incorporating rational expectations. All of these may be affected by financial regulation. When banks increase the spread between borrowing and lending rates for individuals it changes their incomes, and can also change their decision making on the timing of consumption, with the possibility of inducing sharp short term reductions. The volumes of deposits and lending that result are demand determined. Changing the spread between borrowing and lending rates for firms may change the user cost of capital and hence the equilibrium level of output and capital in the economy in a sustained way.

We contend that NiGEM offers the advantage of being a description of the economy and not a theoretical abstract as is true of DSGE models, which may not well describe the economy. The latter is a weakness of models such as Meh and Moran (2008) which seek to identify some potential influence of banks on the economy. The rational expectations features of NiGEM increase realism further and reduce the impact of the Lucas critique. As regards the modelling of banking sectors' influence in terms of spreads between borrowing and lending rates, in a global macromodel this was pioneered by NIESR in its work on the impact of capital adequacy regulation (Barrell et al 2009), where other influences on spreads besides capital include measures of borrower risk. Goodhart (2010) has argued that determining spreads is precisely the way that banks should be incorporated in macro models, and not either ignored or set out in terms of the "money multiplier", see also Woodford (2010). Operating via spreads' impact on investment, the stock of capital and hence, via the production function, output, NiGEM offers a highly realistic and plausible view of the economy and banks' role therein.[18]

[18] We note that the Meh and Moran (2008) paper cited above, bank lending does not operate via spreads explicitly but rather in a form of quantity rationing of ctedit, where it is only after the investment that returns to banks are made xplicit.

We undertook a number of modifications of the existing Swedish model, with first an inclusion of housing wealth in the consumption function. Second, we allowed the increase in household liabilities to be driven by housing wealth (previously it had been driven by income). And third, we included the house price equation set out in column 4 of Table 9, which incorporates an income, wealth and mortgage effect as well as an effect of long real rates and the household sector lending spread (the previous equation had included only the interest rate terms). Hence the effect of banks on the economy via lending spreads is broadened from fixed investment, the stock of capital and consumption to also include house prices. The new equations are shown in Appendix 2

As regards the simulations, we describe seven differing ones. First there is a 0.5 percentage point rise in technical progress, which boosts long term growth. There is a fiscal tightening, which is equivalent to 1% of GDP off government consumption, with the target for the government deficit raised by 1% so tax adjustment is mitigated. There is a fiscal easing which is 1% of GDP on government consumption There is a 3percentage point rise in the intervention rate for 2 years, showing the impact of monetary policy. We then have three macroprudential simulations. One is for a 3 percentage point rise in the bank spread for mortgages only (LENDW) (showing the effect of higher countercyclical capital requirements), for 2 years. We then do this for all bank lending so it also affects the spread for the corporate sector (IPREM). And finally we seek to proxy a fall in regulated LTVs by simply shocking the implicit user cost of housing by 3 percentage points for 2 years. The main difference between LENDW and user cost is simply the effects of LENDW on personal income which is absent for the user cost shock. Then we present the results in a series of tables. Our main focus is on the monetary and macroprudential simulations, the others are there mainly for comparison purposes and to validate the properties of the model.

Table 10 shows the impact of the simulations on GDP. It can be seen that all sectors capital adequacy has a similar effect to monetary policy. This is largely due to the impact of the IPREM variable on investment as the corresponding fall in GDP where only the spread for the housing market is widened is much less, around 0.2% off GDP after 2 years compared to 1.1% for monetary policy and 1.4% for economy wide capital adequacy. Even more subdued is the response of output to the LTV proxy, which by construction does not affect personal income and hence consumption directly, but only affects consumption via the value of housing wealth. Note that we do not build in a possible response of saving to a lower LTV, as people save more to buy a house.

As regards inflation, (Table 11) monetary policy is more effective than macroprudential policies, although there is some effect of the latter also on inflation from the all sectors capital adequacy simulation. We show house prices as a deviation in terms of levels from base in Table 12 . The macroprudential policies are more effective at reducing house prices than monetary policy of the same magnitude (3 pcp for two years). This no doubt relates partly to the term structure effect of the short intervention rate being less than one to one on the long real rate that enters house price determination. The greatest effect is from the all sectors capital adequacy simulation which affects house prices via personal disposable income as well as directly. The other macroprudential policies are quite comparable however.

Table 13 looks at changes in the stock of personal debt. This is driven largely by housing wealth, as shown in Appendix 2 so falls in line with house prices. Again the impact is much greater for macroprudential than monetary policies, calibrated in the manner we have chosen. Table 14 shows housing wealth moving in line with house prices. This variable enters the determination of consumption as does personal disposable income (Table 15) which falls considerably more in the monetary policy than in the macroprudential simulations, although "other personal income" declines in the case of widening spreads in the lending market from LENDW. Note that there is by construction virtually no change to PDI for the case of LTV limits, and we consider this to be realistic.

We finally construct two key macroprudential indicators, namely debt/wealth and debt/personal disposable income and consider how many percentage points the ratios change. In the case of housing market gearing (Table 16) monetary policy raises gearing in each case since it affects housing wealth proportionately more than it does liabilities. In contrast, the macroprudential policies start to reduce the ratio, in the case of an LTV policy in the third year and for the two capital adequacy policies slightly later on. The debt/income ratio (Table 17) is also raised by monetary policy for the first three years, before declining thereafter. The LTV policy, which reduces debt while leaving income unchanged, unambiguously reduces the ratio. For the capital adequacy simulations the effect is again delayed till after the policy is taken off, although there are marked reductions in years 3 to 5 in each case.

Summarising briefly, we need to caution the reader that model simulations can only be imperfectly calibrated. It would be hard to devise a policy that makes an exact change in the spread via capital adequacy equivalent to 3 percentage points, for example. Nevertheless, we contend that the results are of interest in showing that monetary policy is superior in addressing inflation and for the most part output. That said, a rise in capital requirements which gives rise to 3 pcp wider spreads for households and corporations has a major effect on GDP, indeed greater than a 3 pcp rise in intervention rates for the same period. It appears to generate more volatility in GDP for a given macroprudential effect than do the housing market related tools.

In terms of housing market variables, the macroprudential policies seem to be more effective, although monetary tightening also has a major effect on house prices and correspondingly on housing wealth. The restraint of debt by the macroprudential policies is much more effective, operating as it does largely via house prices and housing wealth. We see that an LTV policy can restrain house prices while not impacting on personal income in the same way as capital adequacy based policies. It is correspondingly better at reducing debt/wealth and debt/income ratios, at least in the first two years of the simulation. We should note that the model excludes confidence effects that could differ between these policies, as well as any adjustment to the saving/consumption balance due to LTV restrictions.

Against the background of these results, as well as the theoretical work summarised in Section 6.2, we suggest that the housing market linked macroprudential tools could be a useful complement for monetary policy even in a country like Sweden where there is no constraint on use of monetary policy for domestic stabilisation – and all the more for countries such as those in the Euro zone with a fixed exchange rate.

Conclusion

Against the background of the subprime crisis, where housing was implicated in the financial crisis in countries such as the US, as well as the ongoing discussions regarding Basel III, there has been renewed interest in both macroprudential regulation in general and countercyclical and macroprudential regulation focused on the housing sector in particular. However, although a number of "building blocks" exist, the literature on macroprudential policy in respect of housing is quite thin. There are some descriptions of national experience and some tentative econometrics on the success of such policies, as well as theoretical papers but little beyond that.

We have sought to contribute to reflection in this area by taking a wide point of view and surveying the literature on housing market dynamics with a view to finding possible links to financial instability as well as potential macroprudential tools for dampening disruptive tendencies. We then went on to estimate house price equations and evaluate NiGEM model simulations for Sweden with the same aim.

Summarising our work, we note a number of empirical papers which suggest a link from house prices to banking crises. Notably, we highlight Barrell et al (2010a and b) which show that house prices are a key indicator of banking crises. On the other hand, we also note that housing losses have not tended historically to lead to bank collapses, except in the US where housing loans are non-recourse. It is rather commercial property which is the biggest risk to banks, and the predictive power of house prices might be seen as partly linked to the close relation of the various real estate prices. However, house prices it may also influence banking crises via the wealth effect of housing on consumption, falls in which may drive defaults for producers of consumer goods and services, and for the unemployed.

Such results underpin the growing consensus that housing markets in general and house prices in particular need to be monitored in macroprudential surveillance. Monetary policy can influence house prices via a number of channels, including the user cost of capital, expectations of house price movements, housing supply, wealth effects (although the size of the housing wealth effect is disputed), credit effects on consumption and credit effects on housing demand. Hence, there is an ongoing debate as to whether monetary policy should respond to house prices directly, particularly if there is evidence of deviations from their fundamental determinants. The debate can be summarised by two points of view, whether policy should "lean" against house prices generating potential risk independently of forecasts of inflation and the output gap, or whether it should concentrate on the latter and "clean up" if there is a crisis following a house price collapse.

Notably in countries where monetary policy is taken up with other objectives (e.g. with a fixed exchange rate) there has been ongoing development of policies to influence housing markets via banking regulations, notably limits of allowable loan to value ratios, and variable capital requirements on bank lending for house purchase. These complement the Basel rules which focus on capital regulations across the whole of banks' balance sheets. However, the effectiveness of housing market specific macroprudential regulations is not fully empirically proven beyond their impact on lending, perhaps partly due to the short periods over which they have been introduced in most countries. There are nevertheless some tentative results suggesting that default rates and house prices are affected by such policies.

Policy can only operate effectively on housing in a context where the determinants of house prices are well understood. In the literature, house prices are typically estimated in a cointegrating framework where long and short run influence arise from personal income and a user cost variable (where the latter may incorporate not only interest rates but also taxes and expected house price appreciation). Population and construction costs may also enter. Serial correlation in the short run is a feature of many house price equations. On the other hand, most empirical studies omit some influences that might be expected to impact on house prices. These include financial liberalisation, banking crises, the mortgage stock (especially before liberalisation), unemployment, regulations on housing supply, the housing stock or the flow of investment , financial wealth as a portfolio balance effect, and interest rate spreads on mortgage lending.

In our empirical work, we capture not only the conventional effects but also a number of those typically omitted from existing work, such as banking crises, unemployment, gross financial wealth and the mortgage stock. We find that there are regime shift changes between pre and post liberalisation periods, with a lesser impact of the mortgage stock and a smaller short term income effect after liberalisation. However, long run determinants of house prices are consistent between the two periods, for the most part. Some variables that could be helpful in estimation of the effect of macroprudential policies are absent for most countries, notably a marginal LTV ratio and data on spreads between lending and borrowing rates. The latter was helpfully available for Sweden however. Indeed, estimation of an equation for Sweden includes a significant mortgage spread.

In our estimation we have shown that a number of potential macroprudential effects can be captured in freely estimated house price equations. Notably, we can have effects arising via the user cost, which can proxy LTV limits, spreads, which can proxy for changing capital ratios, as well as a mortgage stock effect.

As noted the mortgage stock effects were stronger in the period before financial liberalisation, which raises the issue of what "regime" tough macroprudential policy will bring the housing market to. Will it lead to renewed rationing and a return to the past, or will it rather be consistent with a free market in house prices and housing finance? In our view the types of policy under consideration are unlikely to be so draconian as to return the housing market to a 1970s style rationing.

Finally, there is evidence from our NiGEM simulations that macroprudential policies can have a distinctive impact on the economy, focused on the housing market, which could helpfully complement monetary policy at most points in the cycle. These results are in turn broadly consistent with the small volume of work assessing theoretically how macroprudential policies may affect the economy. A generalised rise in capital adequacy is shown to have a quite marked impact in GDP, mainly via investment rather than consumption, however. A more focused capital adequacy rise for mortgage lending only or an LTV policy appear to have scope to reduce house prices with less effect on the rest of the economy than other options, although it may of course be more subject than capital adequacy based policies to disintermediation. Capital adequacy for mortgage lending affects GDP more than the LTV policy since it impacts more on personal income and hence consumption. Monetary policy does of course also affect housing market variables but also has a greater effect on the wider economy, as do generalised rises in capital ratios affecting all lending.

Overall, we suggest that the housing market specific macroprudential tools could be a useful complement for monetary policy even in a country like Sweden where there is no constraint on use of monetary policy for domestic stabilisation – and they could be particularly helpful for countries such as those in the Euro zone with a fixed exchange rate.

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Table 1: Data sample

	AU	BG	CN	DK	FN	FR	GE	GR	IR
House prices (PH)	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009	1994-2009	1970-2009
Intervention rate (INT)	1968-2009	1961-2009	1961-2009	1976-2009	1970-2009	1965-2009	1961-2009	1961-2009	1971-2009
Consumers expenditure deflator (CED)	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009
Real personal disposable income (RPDI)	1961-2009	1970-2009	1961-2009	1971-2009	1963-2009	1961-2009	1961-2009	1977-2009	1961-2009
Real long term interest rate (LRR)	1970-2009	1962-2009	1962-2009	1962-2009	1972-2009	1966-2009	1962-2009	1962-2009	1971-2009
Personal debt (LIABS)	1977-2009	1961-2009	1961-2008	1961-2009	1979-2009	1971-2009	1971-2009	1984-2009	1961-2008
Personal net financial wealth (NW)	1970-2009	1961-2009	1961-2008	1961-2009	1979-2009	1970-2009	1971-2009	1964-2009	1975-2008
Unemployment rate (U)	1970-2009	1965-2009	1965-2009	1970-2009	1970-2009	1968-2009	1965-2009	1961-2009	1961-2009
Housing investment (IH)	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1970-2009	1970-2009	1970-2009
Gross domestic product (GDP)	1961-2009	1961-2009	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009	1970-2009
Housing stock estimate (RHS)	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1970-2009	1970-2007	1970-2008
Total population (POP)	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009
20-39 age group (2039)	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010

Note: Country codes are Australia AU, Belgium BG, Canada CN, Denmark DK, Finland FN, France FR, Germany GE, Greece GR, Ireland IR, Italy IT, Japan JP, Netherlands NL, Austria OE, Portugal PT, Sweden SD, Spain SP, the United Kingdom UK and the United States US

Table 1: Data sample continued

	IT	JP	NL	OE	PT	SD	SP	UK	US
House prices (PH)	1970-2006	1961-2009	1970-2009	1970-2009	1988-2009	1970-2009	1971-2009	1964-2009	1970-2009
Intervention rate (INT)	1961-2009	1961-2009	1962-2009	1961-2009	1972-2009	1963-2009	1977-2009	1961-2009	1971-2009
Consumers expenditure deflator (CED)	1961-2009	1965-2009	1961-2009	1970-2009	1970-2009	1961-2009	1961-2009	1961-2009	1961-2009
Real personal disposable income (RPDI)	1965-2009	1970-2009	1970-2009	1970-2009	1970-2009	1961-2009	1964-2009	1961-2009	1961-2009
Real long term interest rate (LRR)	1962-2009	1967-2009	1962-2009	1971-2009	1971-2009	1962-2009	1980-2009	1962-2009	1962-2009
Personal debt (LIABS)	1972-2009	1971-2009	1961-2008	1970-2009	1961-2008	1961-2009	1961-2009	1963-2009	1961-2009
Personal net financial wealth (NW)	1972-2009	1971-2008	1961-2009	1970-2009	1980-2008	1961-2009	1970-2009	1963-2009	1961-2009
Unemployment rate (U)	1978-2009	1961-2009	1965-2009	1961-2009	1961-2009	1975-2009	1965-2009	1971-2009	1961-2009
Housing investment (IH)	1981-2009	1965-2009	1961-2009	1970-2009	n/a	1961-2009	1961-2009	1986-2009	1961-2009
Gross domestic product (GDP)	1970-2009	1965-2009	1970-2009	1970-2009	1961-2009	1961-2009	1964-2009	1961-2009	1961-2009
Housing stock estimate (RHS)	1981-2009	1965-2009	1961-2009	1970-2009	n/a	1961-2009	1961-2009	1986-2009	1961-2009
Total population (POP)	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1961-2009	1971-2009	1961-2009
20-39 age group (2039)	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010	1961-2010

Note: Country codes are Australia AU, Belgium BG, Canada CN, Denmark DK, Finland FN, France FR, Germany GE, Greece GR, Ireland IR, Italy IT, Japan JP, Netherlands NL, Austria OE, Portugal PT, Sweden SD, Spain SP, the United Kingdom UK and the United States US

Table 2: Panel unit root tests

	Level	Difference
Log Real House prices	-2.1 (0.02)	-10.3 (0.00)
Log RPDI	-1.6 (0.06)	-13.6 (0.00)
Real long rate	-2.2 (0.01)	-16.9 (0.00)
Log real liabilities	6.6 (1.0)	-11.7 (0.00)
Log real gross financial wealth	0.5 (0.67)	-15.0 (0.00)
Unemployment rate	-2.3 (0.01)	-10.7 (0.00)
Log housing investment/GDP	-0.8 (0.21)	-15.7 (0.00)
Log real housing stock	-1.7 (0.04)	-3.1 (0.00)
Log 20-39 as a share of population	-5.8 (0.00)	-6.4 (0.00)

Table 3: Panel results – all observations – basic equation

	All	G7	Small countries	Anglo Saxon	Bank dominated
C	**-0.423 (4.8)**	**-0.42 (3.5)**	**-0.67 (4.4)**	**-0.414 (3.2)**	**-0.559 (4.1)**
DLRPDI	**0.81 (8.5)**	**1.0 (6.1)**	**0.644 (5.2)**	**1.16 (6.8)**	**0.683 (5.2)**
DLRR	**-0.0047 (2.3)**	-0.0035 (1.4)	**-0.0058 (1.9)**	**-0.0046 (2.2)**	-0.0044 (1.4)
DLRPH(-1)	**0.534 (13.5)**	**0.511 (7.4)**	**0.547 (11.5)**	**0.432 (6.6)**	**0.577 (12.0)**
LRPH(-1)	**-0.07 (7.1)**	**-0.07 (4.3)**	**-0.088 (6.4)**	**-0.074 (4.0)**	**-0.075 (6.8)**
LRPDI(-1)	**0.048 (4.8)**	**0.048 (3.5)**	**0.079 (4.4)**	**0.04 (3.0)**	**0.068 (4.1)**
LRR(-1)	**-0.0025 (3.5)**	-0.0016 (1.5)	**-0.0036 (3.5)**	**-0.0026 (2.5)**	**-0.0027 (2.8)**
Countries	18	7	11	5	13
Obs	618	268	350	185	433
Adjusted R2	0.53	0.53	0.528	0.555	0.523
SE of regression	0.05	0.048	0.051	0.043	0.053
Durbin Watson	1.79	1.71	1.84	1.82	1.82
Kao	-4.6 (0.00)***	0.17 (0.43)	-4.3 (0.00)***	-1.3 (0.09)*	-3.94 (0.00)***

Note: countries included in "all" are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Asutria, Portugal, Sweden, Spain, the UK and US; "G7" are the UK, US, Germany, Japan, Canada, Italy and France; "small countries" are Australia, Belgium, Denmark, Finland, Greece, Ireland, Netherlands, Austria, Portugal, Sweden, Spain; "Anglo Saxon" are the UK, US, Ireland, Australia and Canada; bank-dominated are Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Austria, Portugal, Sweden, Spain.

Table 4: Panel results – all observations - variants

	All	G7	Small countries	Anglo Saxon	Bank dominated
Cubic (-1)	**-4.9** **(2.9)**	**-9.88** **(4.4)**	-1.05 (0.6)	-6.44 (1.3)	**-4.9** **(3.9)**
Debt (diff)	**0.122** **(6.0)**	0.15 (0.9)	**0.15** **(4.0)**	**0.14** **(3.8)**	**0.13** **(5.2)**
Debt (-1)	-0.001 (0.1)	0.025 (1.3)	**-0.047** **(3.5)**	-0.025 (1,1)	-0.0028 (0.2)
Debt (diff)	**0.152** **(5.1)**	**3.9** **(3.1)**	**0.086** **(2.5)**	**0.16** **(2.8)**	**0.144** **(4.6)**
Debt (diff*unlib)	-0.066 (1.3)	**-3.8** **(2.9)**	**0.35** **(4.4)**	-0.08 (0.8)	-0.034 (4.6)
Debt (-1)	-0.0043 (0.3)	0.02 (0.6)	**-0,047** **(3.5)**	-0.023 (0.9)	-0.004 (0.3)
Debt (-1) *unlib	0.0005 (0.6)	0.0009 (0.6)	0.0002 (0.2)	-0.0022 (1.1)	0.0017 (1.5)
Demog (diff)	0.064 (0.3)	0.16 (0.5)	-0.07 (0.2)	**1.0** **(2.6)**	-0.317 (1.0)
Demog (-1))	0.028 (0.9)	0.012 (0.2)	0.011 (0.3)	**0.127** **(2.4)**	0.011 (0.3)
Investment/GDP (-1)	-0.019 (1.7)	-0.014 (0.9)	**-0.029** **(2.0)**	**0.049** **(2.0)**	-0.017 (1.2)
Housing stock (-1)	0.0009 (0.1)	0.008 (0.2)	**-0.065** **(1.9)**	-0.024 (0.8)	-0.0018 (0.1)
Finlib	-0.005 (0.1)	0.0016 (0.2)	0.007 (0.6)	-0.004 (0.3)	0.007 (0.9)
Crises	**-0.027** **(4.5)**	**-0.021** **(3.1)**	**-0.033** **(2.8)**	**-0.019** **(2.4)**	**-0.4** **(5.1)**
Unempl (diff)	**-0.0093** **(3.8)**	**-0.0096** **(2.6)**	**-0.0097** **(2.8)**	**-0.015** **(4.3)**	-0.0057 (1.6)
Unempl(-1)	0.00085 (0.9)	0.001 (0.6)	0.0005 (0.4)	-0.0024 (1.3)	0.0008 (0.6)
Finwealth (diff)	**0.11** **(2.9)**	0.079 (1.6)	**0.138** **(3.6)**	0.064 (1.4)	**0.153** **(4.1)**
Finwealth (-1)	0.015 (1.3)	**0.043** **(2.1)**	-0.0011 (0.1)	0.031 (1.2)	0.004 (0.3)

Notes (1) Debt growth is instrumented by a constant and lagged growth in RPDI. House prices and real long rates (2) For country groupings see footnote to Table 3

Table 5: Panel results – liberalised – basic equation

	All	G7	Small countries	Anglo Saxon	Bank dominated
C	0.029 (0.15)	0.025 (0.1)	-0.135 (0.4)	-0.088 (0.3)	0.097 (0.3)
DLRPDI	**0.567 (5.0)**	**0.799 (4.3)**	**0.408 (2.8)**	**0.883 (4.8)**	**0.386 (2.7)**
DLRR	**-0.009 (4.1)**	**-0.008 (2.2)**	**-0.012 (3.5)**	**-0.0089 (3.3)**	**-0.0088 (2.4)**
DLRPH(-1)	**0.617 (13.4)**	**0.646 (9.9)**	**0.593 (8.9)**	**0.537 (7.6)**	**0.642 (10.7)**
LRPH(-1)	**-0.06 (5.7)**	**-0.059 (3.4)**	**-0.069 (4.3)**	**-0.067 (3.0)**	**-0.059 (4.7)**
LRPDI(-1)	-0.002 (0.1)	-0.002 (0.1)	0.018 (0.5)	0.0086 (0.3)	-0.01 (0.2)
LRR(-1)	**-0.006 (4.0)**	**-0.0058 (2.2)**	**-0.007 (3.4)**	**-0.0056 (2.0)**	**-0.0069 (3.3)**
Countries	18	7	11	5	13
Obs	413	188	225	133	280
Adjusted R2	0.599	0.625	0.554	0.571	0.605
SE of regression	0.043	0.038	0.047	0.041	0.0448
Durbin Watson	1.76	1.63	1.89	1,83	1.72
Kao	-4.03 (0.00)	-1.97 (0.02)	-2.83 (0.00)	-2.72 (0.00)	-.2.55 (0.00)

Note: For country groupings see footnote to Table 3

Table 6: Panel results – liberalised - variants

	All	G7	Small countries	Anglo Saxon	Bank dominated
Cubic (-1)	-3.27 (1.4)	-4.4 (1.5)	-0.85 (0.3)	-7.1 (1.4)	-3.43 (1.2)
Debt (diff)	**0.19** **(7.9)**	**0.22** **(5.0)**	**0.18** **(4.6)**	**0.19** **(4.3)**	**0.19** **(6.0)**
Debt (-1)	-0.023 (1.7)	-0.053 (1.8)	-0.003 (0.2)	**-0.075** **(2.4)**	-0.017 (1.0)
Demog (diff)	0.07 (0.2)	0.45 (1.1)	-0.506 (1.0)	1.0 (1.8)	0.117 (0.3)
Demog (-1))	0.005 (0.1)	0.044 (0.7)	0.001 (0.1)	**0.21** **(2.4)**	-0.056 (1.0)
Investment/GDP (-1)	0.0007 (0.1)	0.019 (1.0)	-0.014 (0.8)	0.023 (0.8)	0.002 (0.1)
Housing stock (-1)	-0.047 (1.5)	**-0.16** **(3.4)**	0.033 (0.6)	**-0.107** **(2.3)**	-0.005 (0.1)
Crises	**-0.024** **(3.8)**	**-0.019** **(2.7)**	**-0.032** **(2.6)**	**-0.017** **(2.2)**	**-0.036** **(3.9)**
Unempl (diff)	**-0.012** **(4.3)**	**-0.0099** **(2.2)**	**-0.015** **(3.7)**	**-0.014** **(3.2)**	**-0.01** **(2.9)**
Unempl(-1)	**-0.003** **(2.0)**	-0.002 (0.9)	-0.003 (1.6)	-0.0025 (0.9)	**-0.003** **(2.0)**
Finwealth (diff)	**0.114** **(2.9)**	**0.166** **(2.3)**	**0.165** **(2.8)**	0.122 (1.8)	**0.094** **(1.9)**
Finwealth (-1)	-0.019 (0.9)	-0.034 (1.0)	0.062 (1.7)	0.007 (0.2)	-0.057 (1.8)

Note: For country groupings see footnote to Table 3

Table 7: Panel results – all observations – with liberalisation dummies

	All	G7	Small countries	Anglo Saxon	Bank dominated
C	**-0.529 (4.1)**	**-0.559 (2.6)**	**-0.868 (4.3)**	**-0.541 (2.4)**	**-0.692 (3.4)**
DLRPDI	**0.572 (4.6)**	**0.646 (3.3)**	**0.457 (2.5)**	**0.659 (3.6)**	**0.464 (2.7)**
DLRR	**-0.0089 (3.7)**	**-0.008 (2.5)**	**-0.012 (3.0)**	**-0.0089 (3.3)**	**-0.0095 (2.4)**
DLRPH(-1)	**0.67 (12.1)**	**0.758 (9.6)**	**0.54 (6.2)**	**0.63 (8.2)**	**0.695 (8.3)**
LRPH(-1)	**-0.105 (8.8)**	**-0.106 (5.2)**	**-0.132 (7.8)**	**-0.119 (5.1)**	**-0.101 (7.6)**
LRPDI(-1)	**0.061 (4.2)**	**0.062 (2.6)**	**0.104 (4.4)**	**0.055 (2.4)**	**0.085 (3.5)**
LRR(-1)	**-0.0044 (3.2)**	-0.002 (0.8)	**-0.009 (4.6)**	**-0.0037 (2.0)**	**-0.0058 (2.7)**
DLRPDI*LIB	**0.483 (2.2)**	**0.738 (2.0)**	0.422 (1.5)	**1.0 (3.3)**	0.444 (1.6)
DLRR*LIB	0.006 (1.6)	**0.009 (1.9)**	0.007 (1.3)	**0.011 (2.3)**	0.0063 (1.1)
DLRPH(-1) *LIB(-1)	**-0.238 (2.9)**	**-0.462 (3.4)**	-0.026 (0.2)	**-0.395 (3.0)**	-0.2 (1.8)
LRPH(-1) *LIB(-1)	**0.043 (3.9)**	0.026 (1.6)	**0.059 (3.5)**	**0.036 (2.2)**	**0.034 (2.1)**
LRPDI(-1) *LIB(-1)	0.00006 (0.1)	-0.0004 (0.3)	-0.0002 (0.2)	-0.0025 (1.4)	0.0006 (0.6)
LRR(-1) *LIB(-1)	0.002 (1.5)	0.00037 (0.1)	**0.006 (3.0)**	-0.0012 (0.5)	0.0032 (1.5)
Countries	18	7	11	5	13
Obs	618	268	350	185	433
Adjusted R2	0.55	0.57	0.543	0.612	0.536
SE of regression	0.05	0.046	0.05	0.041	0.053
Durbin Watson	1.79	1.69	1.83	1.88	1.82
Kao					

Note: For country groupings see footnote to Table 3

Table 8: Panel results – all observations – variants with liberalisation dummies

	All	G7	Small countries	Anglo Saxon	Bank dominated
Cubic (-1)	-6.87 (1.8)	-4.76 (1.0)	-6.8 (1.4)	-9.6 (1.7)	-8.13 (1.6)
Cubic(-1)*LIB	3.48 (0.8)	-3.78 (0.7)	6.4 (1.2)	8.2 (1.0)	4.2 (0.7)
Debt (diff)	**0.19 (5.9)**	**3.68 (3.2)**	**0.107 (2.9)**	**0.197 (3.1)**	**0.171 (5.1)**
Debt (-1)	0.001 (0.1)	0.02 (0.7)	-0.034 (1.8)	-0.034 (1.3)	0.005 (0.3)
Debt (diff)*LIB	**-0.111 (2.3)**	**-3.61 (3.1)**	**0.327 (3.4)**	-0.137 (1.5)	-0.072 (1.3)
Debt (-1)*LIB	0.0045 (1.2)	0.007 (1.2)	0.001 (0.1)	-0.003 (0.6)	0.005 (0.9)
Demog (diff)	0.41 (1.4)	**0.91 (2.0)**	0.17 (0.3)	**0.987 (2.1)**	0.61 (1.6)
Demog (-1))	0.023 (0.7)	0.033 (0.5)	0.0037 (0.1)	**0.156 (2.1)**	-0.004 (0.1)
Demog (diff)*LIB	**-1.11 (1.8)**	**-1.69 (2.0)**	-0.54 (0.5)	0.856 (0.9)	-1.95 (2.6)
Demog (-1))*LIB	-0.0083 (1.6)	-0.014 (1.6)	-0.007 (0.9)	-0.006 (0.6)	-0.008 (1.3)
Investment/GDP (-1)	-0.013 (1.0)	**-0.049 (2.2)**	-0.017 (0.9)	0.038 (1.4)	-0.013 (1.0)
Investment/GDP (-1)*LIB	0.0037 (0.6)	0.01 (0.9)	0.007 (0.8)	-0.0058 (0.5)	0.0037 (0.6)
Housing stock (-1)	0.02 (1.1)	0.088 (1.8)	-0.008 (0.2)	-0.059 (1.2)	0.024 (1.1)
Housing stock (-1)*LIB	-0.037 (2.4)	-0.04 (1.7)	-0.024 (1.2)	0.077 (1.2)	-0.037 (2.4)
Crises	**-0.021 (3.1)**	-0.0128 (1.6)	-0.025 (1.5)	**-0.018 (2.0)**	**-0.034 (3.8)**
Crises*LIB	-0.006 (0.4)	0.0016 (0.1)	-0.007 (0.2)	**0.203 (2.2)**	-0.001 (0.1)
Unempl (diff)	**-0.0076 (2.5)**	-0.003 (0.7)	**-0.015 (3.5)**	-0.0088 (1.7)	-0.0062 (1.5)
Unempl(-1)	0.001 (0.9)	0.0026 (1.5)	-0.0003 (0.2)	0.0002 (0.1)	0.001 (0.8)
Unempl (diff)*LIB	-0.0063 (1.1)	**-0.021 (2.5)**	0.0076 (1.0)	**-0.0148 (2.2)**	0.0019 (0.2)
Unempl(-1)*LIB	-0.0009 (0.7)	0.0001 (0.1)	-0.0004 (0.2)	**-0.006 (2.2)**	0.0007 (0.4)
Finwealth (diff)	**0.164 (3.8)**	**0.135 (2.0)**	**0.193 (3.6)**	**0.141 (1.9)**	**0.157 (3.0)**
Finwealth (-1)	0.008 (0.6)	0.032 (1.6)	0.02 (0.7)	0.004 (0.2)	-0.007 (0.4)
Finwealth (diff)*LIB	-0.092 (1.6)	-0.068 (0.9)	-0.069 (0.9)	-0.138 (1.6)	-0.0132 (0.2)
Finwealth (-1)*LIB	0.004 (0.7)	0.013 (1.4)	-0.0059 (0.5)	-0.009 (1.1)	0.015 (1.4)

Note: For country groupings see footnote to Table 3

Table 9: Results for Sweden all observations quarterly data 1970Q3-2009Q4

	No RPDI homogeneity	RPDI homogeneity	RPDI homogeneity and LENDW	RPDI and LENDW homogeneity
C	**-0.404** **(3.3)**	**-0.233** **(2.6)**	**0.084** **(0.9)**	**-0.31** **(2.3)**
DLRPDI	**0.695** **(5.0)**	**0.653** **(4.7)**	**0.657** **(4.8)**	**0.609** **(4.3)**
DLRR				
DLRPH(-1)	**0.489** **(8.3)**	**0.521** **(9.1)**	**0.489** **(8.5)**	**0.56** **(10.2)**
LRPH(-1)	**-0.024** **(2.5)**	**-0.026** **(2.7)**	**-0.024** **(2.6)**	**-0.0224** **(2.3)**
LRPDI(-1)	**0.039** **(3.4)**	**0.026** **(fixed)**	**0.024** **(fixed)**	**-0.0224** **(fixed)**
LRR(-1)	-0.098 (1.8)	-0.101 (1,8)	**-0.11** **(2.1)**	**-0.00635** **(1.9)**
DLRPDI*LIB	**-0.667** **(4.2)**	**-0.618** **(3.9)**	**-0.629** **(4.0)**	**-0.572** **(3.5)**
DLRGW	**0.061** **(1.9)**	0.059 (1.8)	**0.061** **(1.9)**	**0.062** **(2.0)**
CRISES	**-0.011** **(2.2)**	**-0.0098** **(2.0)**		
DLRLIABS	**0.063** **(2.1)**	**0.072** **(2.4)**	**0.07** **(2.4)**	**0.0828** **(2.8)**
SPREAD (-1)			**-0.268** **(3.1)**	**-0.00635** **(Fixed)**
R2	0.61	0.61	0.62	0.594
SE	0.014	0.014	0.014	0.014
DW	1.96	1,99	1.97	2.0
LM (4)	4.1	4.6	4.2	3.3
NORM (2)	3.0	1.0	4.6	2.5
HET (1)	4.4*	6.9*	5.2*	5.9*

Note, in last column the real rate and spread are defined as log (real rate/100 + spread/100)

Table 10: Change in GDP

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.34	0.66	0.93	1.15	1.34
Government consumption	-0.22	-0.15	-0.12	-0.11	-0.11
Government consumption	0.24	0.17	0.13	0.10	0.07
Monetary policy tightening	-0.9	-1.14	-0.79	-0.53	-0.33
Housing sector LTV proxy	-0.01	-0.04	-0.05	-0.04	-0.02
Housing sector capital adequacy	-0.05	-0.16	-0.15	-0.12	-0.10
All sectors capital adequacy	-0.72	-1.35	-1.13	-0.90	-0.75

Table 11: Change in inflation

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.28	0.14	0.20	0.18	0.13
Government consumption	0.15	-0.05	0.02	0.04	0.03
Government consumption	-0.10	0.12	0.07	0.04	0.03
Monetary policy tightening	-0.71	-0.06	-0.22	-0.11	-0.01
Housing sector LTV proxy	-0.02	0.00	-0.01	-0.01	-0.01
Housing sector capital adequacy	0.06	-0.01	-0.06	-0.05	-0.04
All sectors capital adequacy	0.06	-0.06	-0.14	-0.07	-0.13

Table 12: Change in house prices

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.41	0.63	0.95	1.32	1.71
Government consumption	0.36	0.39	0.43	0.50	0.59
Government consumption	-0.31	-0.42	-0.63	-0.92	-1.23
Monetary policy tightening	-1.30	-1.79	-2.36	-2.81	-3.01
Housing sector LTV proxy	-0.83	-2.36	-3.03	-2.73	-2.18
Housing sector capital adequacy	-0.89	-2.75	-3.76	-3.66	-3.13
All sectors capital adequacy	-0.86	-2.74	-3.94	-4.11	-3.91

Table 13: Change in stock of personal debt

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.22	0.37	0.56	0.83	1.15
Government consumption	0.39	0.51	0.51	0.52	0.56
Government consumption	-0.25	-0.16	-0.15	-0.33	-0.63
Monetary policy tightening	-0.43	-0.55	-1.11	-1.91	-2.58
Housing sector LTV proxy	-0.24	-1.54	-3.05	-3.56	-3.29
Housing sector capital adequacy	0.17	-0.94	-3.01	-4.13	-4.21
All sectors capital adequacy	0.19	-0.76	-2.76	-4.05	-4.49

Table 14: Change in housing wealth

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.41	0.63	0.95	1.31	1.69
Government consumption	0.36	0.39	0.44	0.50	0.59
Government consumption	-0.31	-0.42	-0.63	-0.92	-1.23
Monetary policy tightening	-1.30	-1.78	-2.35	-2.80	-3.0
Housing sector LTV proxy	-0.83	-2.36	-3.03	-2.73	-2.18
Housing sector capital adequacy	-0.89	-2.75	-3.76	-3.66	-3.13
All sectors capital adequacy	-0.86	-2.74	-3.93	-4.10	-3.89

Table 15: Change in nominal personal disposable income

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	0.31	0.18	0.18	0.20	0.24
Government consumption	-0.18	0.00	0.02	0.05	0.11
Government consumption	0.31	0.18	0.18	0.20	0.24
Monetary policy tightening	-2.49	-3.32	-2.13	-1.86	-1.58
Housing sector LTV proxy	0.04	0.07	0.12	0.17	0.18
Housing sector capital adequacy	-1.74	-2.05	-0.20	0.15	0.26
All sectors capital adequacy	-1.96	-2.81	-1.34	-1.02	-0.79

Table 16: Change in debt/housing wealth ratio

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	-0.19	-0.26	-0.39	-0.49	-0.54
Government consumption	0.03	0.12	0.07	0.02	-0.02
Government consumption	0.05	0.25	0.48	0.59	0.59
Monetary policy tightening	0.87	1.23	1.24	0.89	0.42
Housing sector LTV proxy	0.59	0.82	-0.02	-0.83	-1.12
Housing sector capital adequacy	1.06	1.81	0.75	-0.47	-1.09
All sectors capital adequacy	1.04	1.97	1.17	0.05	-0.60

Table 17: Change in debt/income ratio

Simulation	1 year	2 years	3 years	4 years	5 years
Productivity shock	-0.09	0.19	0.37	0.62	0.91
Government consumption	0.57	0.51	0.49	0.47	0.45
Government consumption	-0.57	-0.34	-0.34	-0.53	-0.88
Monetary policy tightening	2.06	2.77	1.02	-0.05	-1.00
Housing sector LTV proxy	-0.27	-1.60	-3.17	-3.73	-3.48
Housing sector capital adequacy	1.91	1.11	-2.81	-4.28	-4.47
All sectors capital adequacy	2.15	2.04	-1.42	-3.03	-3.70

Appendix 1: The Structure and Use of the NiGEM Model

For a macroeconometric model to be useful for policy analyses, particular attention must be paid to its long-term equilibrium properties. At the same time, we need to ensure that short-term dynamic properties and underlying estimated properties are consistent with data and well-determined. As far as possible, the same long run theoretical structure of NiGEM has been adopted for each of the major industrial countries, except where clear institutional or other factors prevent this. As a result, variations in the properties of each country model reflect genuine differences in data ratios and estimated parameters, rather than different theoretical approaches. The model has been in use at the National Institute since 1987, but it has developed and changed over that time. Some of its development was initially financed by the ESRC, but since 1995 it has been funded by its user community of public sector policy institutions. These currently include the Bank of England, the ECB, the IMF, the Bank of France, the Bank of Italy and the Bundesbank as well as most other central banks in Europe along with research institutes and finance ministries throughout Europe and elsewhere.

Each quarter since 1987 the model group has produced a forecast baseline that has been published in the Institute *Review* and used by the subscribers as a starting point for their own forecasts. The forecast is currently constructed and used out to beyond 2031 each quarter, although the projection beyond 2015 is a stylized use of the long run properties of the model. Since 1998, the model has also been used by the EFN Euroframe group to produce forecasts for the European Commission. Forecasts are produced based on assumptions and they do not always use forward looking behaviour. In policy analyses the model can be switched between forward looking, rational expectations mode and adaptive learning for consumers, firms, labour and financial markets. Policy environments are very flexible, allowing a number of monetary and fiscal policy responses. The model has been extensively used in projects for the European Commission, UK government departments and government bodies throughout the world. It has also contributed to a number of Institute ESRC projects.

Production and price setting
The major country models rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress.

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-1/\rho} \qquad \text{(A1)}$$

where is Q is real output, K is the total capital stock, L is total hours worked and t is an index of labour-augmenting technical progress. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feed into the price system. Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital output ratio depends on the real user cost of capital

$$Ln(L) = \left[\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p) \qquad \text{(A2)}$$

$$Ln(K) = \left[\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - \sigma \ln(c/p) \qquad \text{(A3)}$$

where w/p is the real wage and c/p is the real user cost of capital. The user cost of capital is influenced by corporate taxes and depreciation and is a weighted average of the cost of equity finance and the margin adjusted long real rate, with weights that vary with the size of equity markets as compared to the private sector capital stock. Business investment is determined by the error correction based relationship between actual and equilibrium capital stocks. Government investment depends upon trend output and the real interest rate in the long run. Prices are determined as a constant mark-up over marginal costs in the long term.

Labour market

NiGEM assumes that employers have a right to manage, and hence the bargain in the labour market is over the real wage. Real wages, therefore, depend on the level of trend labour productivity as well as the rate of unemployment. Labour markets embody rational expectations and wage bargainers use model consistent expectations. The dynamics of the wage market depend upon the error correction term in the equation and on the split between lagged inflation and forward inflation as well as on the impact of unemployment on the wage bargain (Anderton and Barrell 1995). There is no explicit equation for sustainable employment in the model, but as the wage and price system is complete, the model delivers equilibrium levels of employment and unemployment. An estimate of the NAIRU can be obtained by substituting the mark-up adjusted unit total cost equation into the wage equation and solving for the unemployment rate. Labour supply is determined by demographics, migration and the participation rate.

Consumption, personal income and wealth

Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C) = \alpha + \beta \ln(RPDI) + (1 - \beta)\ln(RFN + RTW) \quad \text{(A4)}$$

where *C* is real consumption, *RPDI* is real personal disposable income, *RFN* is real net financial wealth and *RTW* is real tangible wealth. The dynamics of adjustment to the long run are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints. As Barrell and Davis (2007) show, changes in financial (dlnNW) and especially housing wealth (dlnHW) will affect consumption, with the impact of changes in housing wealth having five times the impact of changes in financial wealth in the short run. They also show that adjustment to the long run equilibrium shows some inertia as well.

$$\text{dln}C_t = \lambda(\ln C_{t-1} - \ln PI_{t-1}) + b_1\text{dlnRPDI}_t + b_2\text{dlnNW}_t + b_3\text{dlnHW}_t \quad \text{(A5)}$$

Al Eyd and Barrell (2005) discuss borrowing constraints, and investigate the role of changes in the number of borrowing constrained households. It is common to associate the severity of borrowing constraints with the coefficient on changes in current income (dlnRPDI) in the equilibrium correction equation for consumption, where d is the change operator and ln is natural log,

Financial markets

We generally assume that exchange rates are forward looking, and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and risk premia, solving an uncovered interest parity condition, and these, in turn, are determined by policy rules adopted by monetary authorities as discussed in Barrell, Hall and Hurst (2006):

$$RX(t) = RX(t+1)[(1+rh)/(1+ra)](1+rprx) \quad \text{(A6)}$$

where *RX* is the exchange rate, *rh* is the home interest rate set in line with a policy rule, *ra* is the interest rate abroad and *rprx* is the risk premium. . Nominal short term interest rates are set in relation to a standard forward looking feedback rule. Forward looking long rates are related to expected future short term rates

$$(1+LR_t) = \Pi^T_{j=1},\ (1+SR_{t+j})^{1/T} \qquad \text{(A7)}$$

We assume that bond and equity markets are also forward looking, and long-term interest rates are a forward convolution of expected short-term interest rates. Forward looking equity prices are determined by the discounted present value of expected profits

Public sector

We model corporate (CTAX) and personal (TAX) direct taxes and indirect taxes (ITAX) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate (TAXR) to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (GI) and consumption (GC) rising in line with trend output in the long run, with delayed adjustment to changes in the trend. They are re-valued in line with the consumers' expenditure deflator (CED). Government interest payments (GIP) are driven by a perpetual inventory of accumulated debts. Transfers (TRAN) to individual are composed of three elements, with those for the inactive of working age and the retired depending upon observed replacement rates. Spending minus receipts give us the budget deficit (BUD), and this flows onto the debt stock.

$$BUD = CED*(GC+GI)+TRAN+GIP-TAX-CTAX-MTAX \qquad (8)$$

We have to consider how the government deficit (BUD) is financed. We allow either money (M) or bond finance (debt).

$$BUD = \Delta M + \Delta DEBT \qquad (9)$$

rearranging gives:

$$DEBT = DEBT_{t-1} - BUD - \Delta M \qquad (10)$$

In all policy analyses we use a tax rule to ensure that Governments remain solvent in the long run (Barrell and Sefton 1997),. This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = f(\text{target deficit ratio} - \text{actual deficit ratio}) \qquad (11)$$

If the Government budget deficit is greater than the target,(e.g. -3 % of GDP and target is -1% of GDP) then the income tax rate is increased.

External trade

International linkages come from patterns of trade, the influence of trade prices on domestic price, the impacts of exchange rates and patterns of asset holding and associated income flows. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs. The estimated relationships also include measures to capture globalization and

European integration and sector-specific developments. It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices; and demand is given by a share of imports in the markets to which the country has previously exported. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. As exports depend on imports, they will rise together in the model. The overall current balance depends upon the trade balance and net property income form abroad which comprised flows of income on gross foreign assets and outgoings on gross foreign liabilities. Gross National Product (GNP) is gross Domestic Product (GDP) plus net factor income from foreigners.

Appendix 2: New equations for Swedish NiGEM

Addition to credit rate (SDCR)

This allows an extra wedge to be incorporated in the interest rate relevant for house prices to proxy an LTV cap.

```
#  sdcr = sdcr(-1)
```

House prices (SDPH)

As described in the text, real house prices are in an error correction relationship with real personal disposable income, and the long real rate, adjusted for the credit rate as above (sdcr) and the bank spread (sdlendw). There is also a link in the short run to real gross financial wealth and to real household debt.

```
log(sdph)= log(sdced) + log(sdph(-1)/sdced(-1)) -0.3104
+ 0.03*(log(sdrpdi)-log(sdrpdi(-1)))+ 0.5598*(log(sdph(-1)/sdced(-1))
- log(sdph(-2)/sdced(-2))) - 0.0224*(log(sdph(-1)/sdced(-1))-log(sdrpdi(-1)))
- 0.0063*log((sdlrr(-1)/100)+(sdlendw(-1)/100)+sdcr(-1)) +
0.0663*(log((sdnw+sdliabs)/sdced)
- log((sdnw(-1)+sdliabs(-1))/sdced(-1))) + 0.0828*(log(sdliabs/sdced)
- log(sdliabs(-1)/sdced(-1)))
```

Value of personal sector housing stock (SDHW)

This is a technical equation that ensures that housing wealth is adjusted in line with housing investment and house prices

```
 sdhw  = sdhw(-1)*(sdph/sdph(-1))*(1.-.01*0.25)
    + .01*sdph*0.6*(sdih-0.0059*sdy)
```

Private consumption, Mn SEK, 2000 prices (SDC)

The Swedish consumption function in NiGEM is an error correction relationship including real personal disposable income, total wealth (financial plus housing) and the retired share pf the adult population.

```
dsdcrr = dwdcrr*((1.- 0.22145)*(1.-0.037433)*0.00125*sdrr(-1)
               -(1.- 0.22145)*0.00125*sdrr)
log(sdc) = log(sdc(-1)) + 0.0402 + dsdcrr  -  0.074257*(  log(sdc(-1))
 +0.5*sdpopr/(sdpopr+sdpopwa)
 - 0.92266* log(sdrpdi(-1))
- (1.-0.92266)* log((sdnw(-1)+sdhw(-1))/sdced(-1)))
 +0.03866*log((sdnw/sdced)/(sdnw(-1)/sdced(-1)))
+ 0.10885*log(((sdhw/(0.01*sdced))*100.)/((sdhw(-1)/(0.01*sdced(-1))) *100.))
+sdcliq*log(sdrpdi/sdrpdi(-1))
```

Gross liabilities personal sector, Mn SEK (SDLIABS)

Personal gross liabilities rise in line with personal disposable income and housing wealth

```
log(sdliabs) = log(sdliabs(-1))
       + 0.1232 - 0.2576*((log(sdliabs(-1))-log((sdpi(-1)-sdtax(-1))))
       - 0.1691*(sdhw(-1)/(sdpi(-1)-sdtax(-1))))
```

Other variable definitions

SDRPDI	Real personal disposable income
SDPI	Personal disposable income
SDTAX	Income tax rate
SDNW	Personal net financial wealth
SDCED	Consumers expenditure deflator
SDY	Real GDP
SDIH	Real housing investment
SDLRR	Real long term interest rate
SDLENDW	Spread between household borrowing and deposit rate
SDPOPR	Retired population
SDPOPWA	Working age population
SDCLIQ	Proportion of population facing liquidity constraints
SDSCRR	Technical variable permitting the effect of indirect taxes on inflation to be removed