Low Interest Rates and Housing Booms: the Role of Capital Inflows, Monetary Policy and Financial Innovation

Filipa Sá* Pascal Towbin† Tomasz Wieladek‡§

October 2010

Abstract

A number of OECD countries experienced an environment of low interest rates and a rapid increase in housing market activity during the last decade. Previous work suggests three potential explanations for these events: expansionary monetary policy, capital inflows due to a global savings glut and excessive financial innovation combined with inappropriately lax financial regulation. In this study we examine the effects of these three factors on the housing market. We estimate a Panel VAR for a sample of OECD countries and identify monetary policy and capital inflows shocks using sign restrictions. To explore how these effects change with the structure of the mortgage market and the degree of securitisation, we augment the VAR to let the coefficients vary with mortgage market characteristics. Our results suggest that both types of shocks have a significant and positive effect on real house prices, real credit to the private sector and residential investment. The responses of housing variables to both types of shocks are stronger in countries with more developed mortgage markets. The amplification effect of mortgage-backed securitisation is particularly strong for capital inflows shocks.

*Trinity College, University of Cambridge, fgs22@cam.ac.uk

†Banque de France, Pascal.Towbin@banque-france.fr

‡Bank of England, Tomasz.Wieladek@bankofengland.co.uk

§This is preliminary work. The views expressed in this paper are only those of the authors, and not necessarily those of the Bank of England or the Banque de France. The Authors wish to thank Shekhar Aiyar, Martin Brooke, Stefan Gerlach, Glenn Hoggarth, Daniel Kaufmann, Lavan Mahadeva, Gregory Thwaites, Cédric Tille, Sebastian Weber, Charles Wyplosz, and participants at the Bundesbank, the Swiss Young Economists' Meeting 2010, RES Conference 2010, Surrey, EEA Conference 2010, Glasgow, and Trinity College, Dublin, for helpful comments and suggestions.

1 Introduction

During the past decade a number of OECD countries experienced a rapid increase in housing market activity, which coincided with a period of low interest rates. The link between the two is intuitive: low interest rates make credit cheaper and increase the demand for housing. Some scholars argue that expansionary monetary policy has been significantly responsible for this low level of interest rates and the subsequent house price boom (Hume and Sentance, 2009, Taylor, 2009). Others stress the role of excessive saving in financially underdeveloped economies which led to persistent capital inflows into rich countries and thus depressed long rates (Caballero et al. 2008; Warnock and Warnock, 2009). A third, hotly debated, issue is how mortgage market structure and securitization affect the transmission of low interest rates to the housing sector. In more developed mortgage markets, consumers have easier access to credit and tend to be more leveraged. In the presence of financial frictions, the impact of changes in interest rates on consumers and therefore the housing market should become stronger when leverage is higher. Similarly, Diamond and Rajan (2009) argue that excessive financial innovation has led to a misallocation of capital to the real estate sector through securitization, exacerbating the effect of interest rate movements on housing activity. Each of these explanations has different policy implications. Should policy makers try to address external imbalances, increase financial regulation or redesign the monetary policy framework to prevent future crises?

In this study we develop an empirical framework to assess the effects of capital inflows, monetary policy and financial innovation on the housing sector. Our first contribution is to document the effects of monetary policy and capital inflows on the housing sector in a broad sample of advanced economies. We estimate a Panel VAR for eighteen OECD countries and identify capital inflows and monetary policy shocks with sign restrictions. There are a number of recent studies that use structural VARs to analyze the transmission of monetary policy shocks to housing variables in advanced economies - for example, Assenmacher-Wesche and Gerlach (2010), Carstensen et al. (2009), Calza et al. (2009), Goodhart and Hoffmann (2008) . The general conclusion of these studies is that an unexpected monetary policy loosening increases housing activity. We extend this literature by looking not only at the effects of monetary policy on the housing market, but also at the effects of capital inflows.

There is a substantial literature that deals with the "capital inflows problem" and its implication for asset prices in developing economies (see, for example, Calvo et al., 1994). However, the link between housing activity and capital inflows in developed economies has been much less studied. Reinhart and Reinhart (2008) study periods of large capital inflows in both advanced and emerging economies from 1980 to 2007. They find that these periods are associated with a real exchange rate appreciation and booms in equity and house prices. Aizenman and Jinjarak (2009) show that there is a negative relationship between the size of current account surpluses and the change in real house prices in a broad sample of developed and developing countries. In a recent speech, Bernanke (2010)

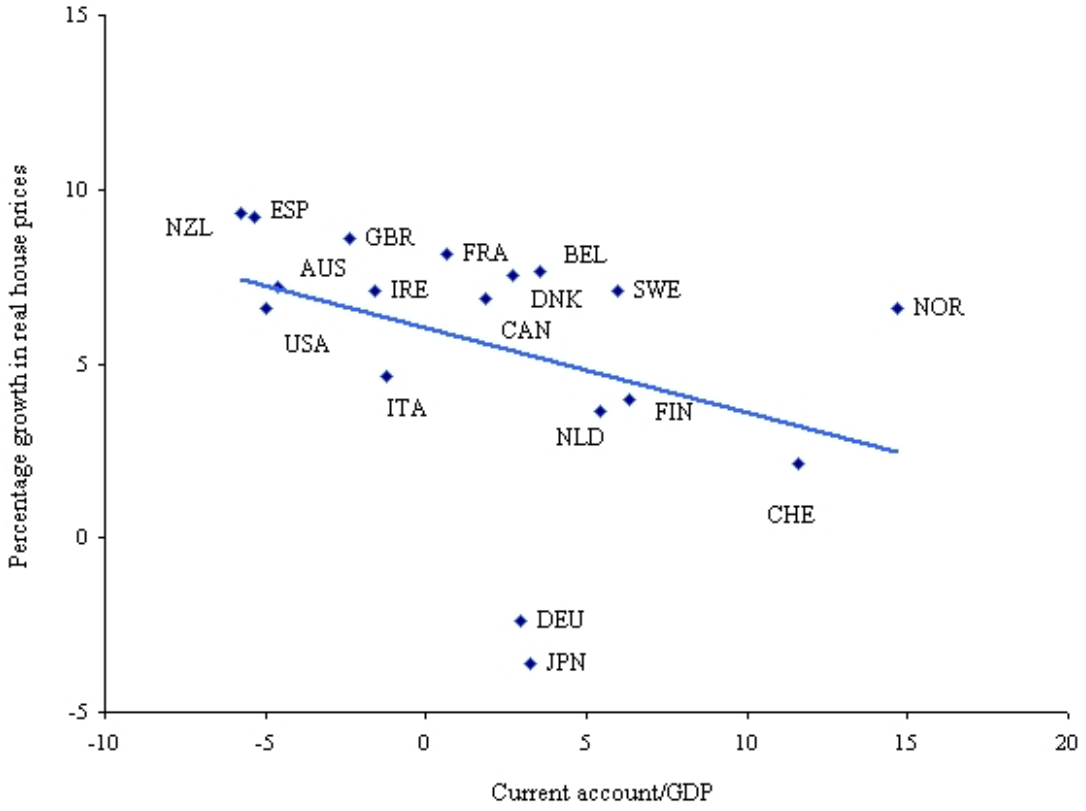

Figure 1: Capital Infows and House Prices (Quarterly Average 2001q1-2007q4)

also makes the point that house prices increase by more in countries with larger increases in capital inflows and suggests that this would be a promising avenue for explaining cross-country differences in house price growth. Figure 1 confirms this result for our sample of OECD countries. This negative correlation suggests the presence of an important link between the current account balance and the housing sector, but the direction of causality is unclear. Sá and Wieladek (2010) use a VAR approach with sign restrictions to identify capital inflows shocks and find that they explain a substantial amount of real house price and residential investment variation in the United States. In this study we look at whether this pattern is present in a broader sample of countries.

Having studied the effect of monetary policy and capital flows shocks on housing activity, our second contribution is to explore how financial innovation affects the transmission of the two shocks. Using an index of mortgage market development constructed in IMF

(2008)[1], we split our sample in two groups of countries (with high and low mortgage market development) and estimate our Panel VAR model across the two subsamples. We also split the sample using alternative cross-sectional mortgage market characteristics.

Comparing impulse responses across countries with high and low levels of mortgage market development accounts for cross-sectional variation, but assumes that there is no variation in the mortgage market structure over time. To exploit the variation in mortgage market development over time, we use two time-varying indices: an index of mortgage market securitisation constructed by Hoffman and Nitschka (2009) Following a similar approach as Towbin and Weber (2010), we use an interacted Panel VAR to exploit the time variation in the indices. By interacting all variables with an index of mortgage-backed securitization, we allow the responses to vary with the degree of securitization.

Some previous studies have looked at whether the structure of the mortgage market plays a role in the propagation of monetary policy shocks. Calza et al. (2009) and Assenmacher-Wesche and Gerlach (2010) find that higher mortgage market development amplifies the effects of monetary policy shocks on housing variables. Both studies estimate Panel VARs across two groups of countries, classified according to their degree of mortgage market development using various cross-sectional indicators. Our approach is similar to theirs but differs in three important ways. First, we identify the effect of capital inflows shocks in addition to monetary policy shocks. Second, we use sign restrictions rather than zero restrictions for identification of the shocks.[2] Third, we extend the analysis to an interacted Panel VAR which allows us to study the effects of time-varying characteristics of the mortgage market without having to split the sample in sub-groups.

To preview the results, we find that both capital inflows and monetary policy shocks have a statistically significant effect on real private credit, real residential investment, and real house prices. Moreover, capital inflows do not appear to be associated with inflationary pressures or with substantial increases in output, suggesting that a central bank that follows a standard Taylor rule would see little reason to respond to these shocks. When comparing the responses of these variables in countries with different degrees of mortgage market development, we find that both shocks have a larger effect on housing activity in countries with a more developed mortgage market. Securitization also tends to amplify both types of shocks, but the amplification effect is stronger for capital inflows shocks.

The remainder of the chapter proceeds as follows. Section 2 looks at the literature on the transmission channels of interest rates to housing activity and discusses how financial innovation may amplify those channels. Section 3 discusses the methods and data. Section 4 presents the main results and Section 5 discusses various robustness checks. Section 6 concludes.

[1]The IMF index takes a higher value if typical loan to value ratios are high, there is the possibility of mortgage equity withdrawal (i.e. consumers can borrow against the value of their houses to finance spending), secondary mortgage markets exist, and mortgage contracts are predominantly long term).

[2]See Canova and de Nicoló (2002) or Uhlig (2005) for a critique of the use of zero restrictions to identify monetary policy shocks.

2 The Transmission Channels of Interest Rates to Housing Activity

Bernanke and Gertler (1995) and Mishkin (2007) survey the literature on potential transmission channels between interest rates and the real economy. While their focus is on interest rate changes caused by monetary policy, the same channels would be in place for interest rate changes caused by capital inflows. In a neoclassical world the "user cost of capital" is the only transmission channel: lower interest rates on bonds decrease the opportunity costs of buying a house and increase the demand for houses. In the presence of information asymmetries between borrowers and lenders or other types of financial frictions, there is an additional transmission channel — the "financial accelerator" effect, developed in the seminal papers of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997).

Bernanke and Gertler (1989) focus on the investment decision of firms. There is asymmetric information between lenders and entrepreneurs: while entrepreneurs know the profitability of their investment projects, lenders must pay an auditing cost to observe the project's return. This information asymmetry is the key source of persistence in the model. A positive productivity shock increases savings of entrepreneurs and lowers agency costs, making it easier for them to obtain external finance. As a result, more investment projects are financed, which creates employment for young agents and leads to further income expansion in subsequent periods. Kiyotaki and Moore (1997) add an additional element to this story: the idea that the net worth of borrowers changes not only in response to variations in cash flows, but also to changes in the value of their assets. In their framework agents can only borrow against collateral (for example land) and the amount they can borrow depends on the value of collateral. The need for collateral in this model arises not because of asymmetric information but because of limited commitment, i.e. lenders cannot force borrowers to work in order to repay their debt. The dynamic interaction between the borrowing constraint and the value of collateral generates both persistence and amplification. A temporary negative productivity shock reduces borrowers' net worth and tightens their credit constraint. Borrowers cut back on their investment expenditure (including investment in land) and their net worth next period falls as they earn less revenue. This is analogous to the persistence effect in Bernanke and Gertler. But there is an additional effect that operates through the price of land. To ensure market clearing, demand for land by lenders has to rise, which requires a reduction in the user cost of land (the difference between that period's land price and the discounted value of the land price in the following period). The anticipated decline in user costs in subsequent periods leads to an even larger fall in the price of land in the current period, since the price of land equals the discounted value of future user costs. The fall in the price of land reduces net worth of borrowers in the current period even further and has a large impact on their investment spending since they are highly leveraged. There is an amplification effect that occurs because the price

of land is forward looking and borrowers are highly leveraged. The empirical relevance of the "financial accelerator " effect has been studied, for example, in Bernanke, Gertler and Gilchrist (1999). This study presents a dynamic general equilibrium model that incorporates both the persistence effect in the original Bernanke and Gertler (1989) model and endogenous changes in asset price which generate further amplification, as in Kiyotaki and Moore (1997).

A number of studies (see, for example, Iacoviello, 2005 or Calza et. al, 2009) apply the financial accelerator to to the housing market, where a similar mechanism is at work. A reduction in interest rates increases the value of collateral (housing) by increasing the discounted value of future user costs. The borrowers' debt capacity and consequently the demand for housing increases further, generating an even larger increase in house prices. Persistence and amplification would be mutually reinforcing and propagate the effect of the initial shock to interest rates on housing activity. The studies predict the transmission channels to be stronger in countries with more developed mortgage markets. Higher loan to value ratios reinforce the amplification effect described in Kiyotaki and Moore (1997) as households are more leveraged and their net worth is more affected by fluctuations in the value of collateral. The possibility of mortgage equity withdrawal (i.e., the possibility to borrow against the value of the house to finance spending) should have a similar effect. Countries where it is less costly to refinance mortgages should also see stronger transmission from interest rates to housing activity, since interest rate reductions would feed through to lower mortgage rates not only for new mortgages but also for existing ones. This would lower the cost of credit and increase housing demand.

There is yet an additional channel through which interest rates may affect house prices —the "risk taking channel", proposed by Rajan (2005) and Borio and Zhu (2008). According to this theory, low interest rates encourage financial intermediaries to take more risk, for example because they target a certain rate of return and need to take more risk to achieve that target when risk-free interest rates are lower (a "search for yield" effect). This would lead to an increase in demand for riskier assets, driving up their prices. The underpricing of risk may also lead to more lenient lending standards, for example higher loan to value ratios or lending to households with higher default risk. This would increase borrowers' leverage and strengthen the amplification effect of changes in collateral values described above. Hence, there may be an interesting interaction between the "risk taking channel" and the "financial accelerator".

Diamond and Rajan (2009) argue that securitization also plays an important role in the transmission of interest rate shocks to the housing market. Securitization allows banks to share risks by moving them off their balance sheets. This leads to an increase in banks' risk appetite and strengthens the "risk taking channel" described above. To the extent that banks become more lenient in their lending standards, the "financial accelerator" effect may be strengthened as well. By amplifying these transmission channels, securitization may play

a role in propagating the effects of interest rate reductions on housing activity.[3] Diamond and Rajan also highlight that securitization facilitates foreign investment in mortgage loans. Without securitization, it is difficult for foreign investors to hold home mortgage loans directly, because they are of uncertain credit quality and have a higher propensity to default than other assets. Securitization packages mortgages together and slices them in different levels of risk. The riskiest tranches can be bought by investors with higher risk appetite, while the AAA tranches can be sold to international investors. In this way, securitization increases the share of foreign capital inflows allocated to home mortgage loans. This would suggest that securitization may have a particularly strong role in the transmission of capital inflows shocks to the housing market.

3 Methodology

3.1 Empirical Model and Data

3.1.1 Baseline model

We estimate the following VAR model for a panel of eighteen OECD countries:[4]

$$Y_{i,t} = A_{i,0} + \sum_{k=1}^{L} A_{i,k} Y_{i,t-k} + u_{it} \quad t = 1, ...T \;\; i = 1, ..., N \;\; u_{i,t} \sim N(0, \Sigma) \tag{1}$$

where $Y_{i,t}$ is a $q \times 1$ vector of explanatory variables, $A_{i,0}$ is a $q \times 1$ vector of country specific intercepts, $A_{i,k}$ is a $q \times q$ matrix of autoregressive coefficients up to lag L, and u_{it} is the $q \times 1$ vector of one step ahead prediction errors, normally distributed with a $q \times q$ covariance matrix Σ.

The VAR includes ten variables: the 3-month (short term) nominal interest rate on government debt, the 10-year (long term) nominal interest rate on government debt, real GDP, the consumer price index, the current account balance to GDP ratio, the trade-weighted real exchange rate, a commodity price index, real credit to the private sector, real residential investment, and real house prices.[5]

[3] This does not imply that securitization has a generally harmful effect on the economy. For example, Hoffmann and Nitschka (2009) find that securitization has improved international risk-sharing. Going forward, improvements in financial regulation and the functioning of securitization markets could work to reduce this amplification effect.

[4] The sample includes Australia, Belgium, Canada, Finland, France, Denmark, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[5] We follow a large literature in monetary economics (see Christiano, Eichenbaum and Evans, 1999) and include all of the variables in levels. Canova (2005) suggests that if the researcher is uncertain whether the variables included in the VAR are stationary, the best solution is to include potentially non-stationary variables in levels. Sims, Stock and Watson (1990) show that VAR coefficient estimates are also consistent with non stationary variables. With a standard Normal-Wishart prior Bayesian inference is not affected by

The first seven variables contain information about the general state of the economy and help to identify monetary policy and capital inflows shocks. The model includes both short term and long term interest rates. In our sample of countries short term interest rates are largely controlled by central banks. Using movements in nominal short rates to identify monetary policy shocks is standard in VARs that study monetary policy (see e.g. Christiano et al., 1999). Long term interest rates, on the other hand, tend to be driven by financial market outcomes. As a result, one would expect to observe the effects of capital inflows shocks on long rates rather than short rates. We include commodity prices because previous studies have shown that they are important to explain movements in the price level (Sims, 1992).

To capture several features of the housing sector, we look at three variables: real credit to the private sector, residential investment, and real house prices. Apart from interest rates, all variables are in logs. The data is taken from the OECD Economic Outlook, the IMF International Financial Statistics (IFS), and the BIS Macro database. The variables and data sources are listed in the Appendix. We estimate the model on quarterly data over the period of the Great Moderation from 1984 Q1 to 2007 Q2 with two lags.[6] We therefore exclude the turbulent years of the high inflation period from the late 1970s to the early 1980s and of the recent financial crisis.

Using a panel rather than a single country framework increases the number of observations and leads to more precise estimates. However, transmission mechanisms are likely to vary across countries, for example, due to differences in institutional arrangements. We assume that both the intercept and slope coefficients can vary across countries: $A_{i,0} = A_0 + \varepsilon_{i,0}$, $A_{i,k} = A_k + \varepsilon_{i,k}$, where A_k is the average coefficient and $\varepsilon_{i,k}$ captures country specific variation. Pesaran and Smith (1995) show that the standard fixed effects estimator, which only allows for heterogenous intercepts but imposes homogeneous slopes, is inconsistent in dynamic panels if there is also slope heterogeneity. Applying the fixed effects estimator leads to serial correlation in the residuals. A combination of serially correlated residuals and regressors will therefore lead to inconsistent estimates. Pesaran and Smith (1995) propose the mean group estimator as a solution to this problem. We implement this estimator by interacting all variables with country dummies $D_{i,k}$ for $i = 1, ..., N$. The procedure amounts to a generalized version of the standard fixed effects estimator that adds fixed effects on the slope coefficients. The interacted country dummies capture all country specific time-invariant variation $\varepsilon_{i,k} = D_{i,k}$. We begin our empirical analysis by looking at the impulse responses implied by the estimated average coefficients.

non-stationarity (Sims, 1988).

[6] Hannan Quinn and Schwarz Information Criteria suggest a lag lenght between one and two for individual countries. We follow Calza et.al. (2009) and choose a lag length of two. We obtain similar results when using one or three lags instead.

3.1.2 Cross-sectional Heterogeneity in Mortgage Market Structure

As a next step we investigate the effect of the mortgage market structure on the transmission of shocks. As documented in IMF (2008) there is substantial heterogeneity in mortgage market development across countries. While in Anglo-Saxon and Nordic countries deregulation of mortgage markets was relatively rapid and was completed by the mid-1980s, in Japan and continental Europe the process was more gradual.

In more developed mortgage markets consumers should have easier access to credit because of stronger competition and a greater variety in funding sources and loan products. We use the index constructed in IMF (2008) as a summary measure for a number of variables that characterize mortgage market development. The index takes a high value if typical loan to value ratios are high, there is the possibility of mortgage equity withdrawal (i.e. consumers can borrow against the value of their houses to finance spending), households are able to refinance their mortgages without paying fees, secondary mortgage markets exist, and mortgage contracts are predominantly long-term. Because of limited data availability the index is time invariant and refers to the mid-2000s. In the next section we adapt the model to look at the effect of some time-varying measures of mortgage market structure.

We use this index to split countries into two groups: one group with highly developed mortgage markets (HDM) and another with less developed mortgage markets (LDM).[7] Figure 2 shows that the Anglo-Saxon and Nordic countries tend to have a highly developed mortgage market, whereas most countries in continental Europe are in the less developed group.[8] In the baseline analysis we work with the overall index. To assess the robustness of the results, we then look at some of its subcomponents, splitting countries according to the typical loan to value ratio and the possibility of mortgage equity withdrawal. As an alternative to the IMF index, we also split countries using the ratio of mortgage debt to GDP in 2004 taken from the tables in Calza et al (2009). The resulting country groups are listed in the Appendix.

The effect of time invariant features of the mortgage market on the dynamics is fully captured by the country specific variation $\varepsilon_{i,k}$ in the VAR coefficients. Let $\varepsilon_{i,k} = mor_{i,k} + \eta_{i,k}$ where $mor_{i,k}$ stands for the effects of country specific variation in the mortgage market and $\eta_{i,k,}$ for other differences unrelated to the mortgage market. Because $\eta_{i,k,}$ has mean zero, the effects of mortgage market development can then be estimated by computing the average coefficient for the highly developed and the less developed markets separately: $mor_{HDM,k,} = \frac{1}{N_{HDM}} \sum_{i \in HDM} \varepsilon_{i,k}$ and $mor_{LDM,k,} = \frac{1}{N_{LDM}} \sum_{i \in LDM} \varepsilon_{i,k}$. We can interpret the impulse responses implied by VAR coefficient matrices $A_{HDM,k} = A_k + mor_{HDM,k}$ and

[7] For Switzerland we use the value calculated by Assenmacher-Wesche and Gerlach (2010). Because the index is not available for New Zealand, it is excluded from the sample.

[8] We split the sample at the median value. Attributing Finland (the country with the median value) to the highly developed group or excluding it from the sample does not affect our results. Our results are also qualitatively robust if several high mortgage market development countries close to the median value of the index are attributed to the low mortgage market group and vice versa.

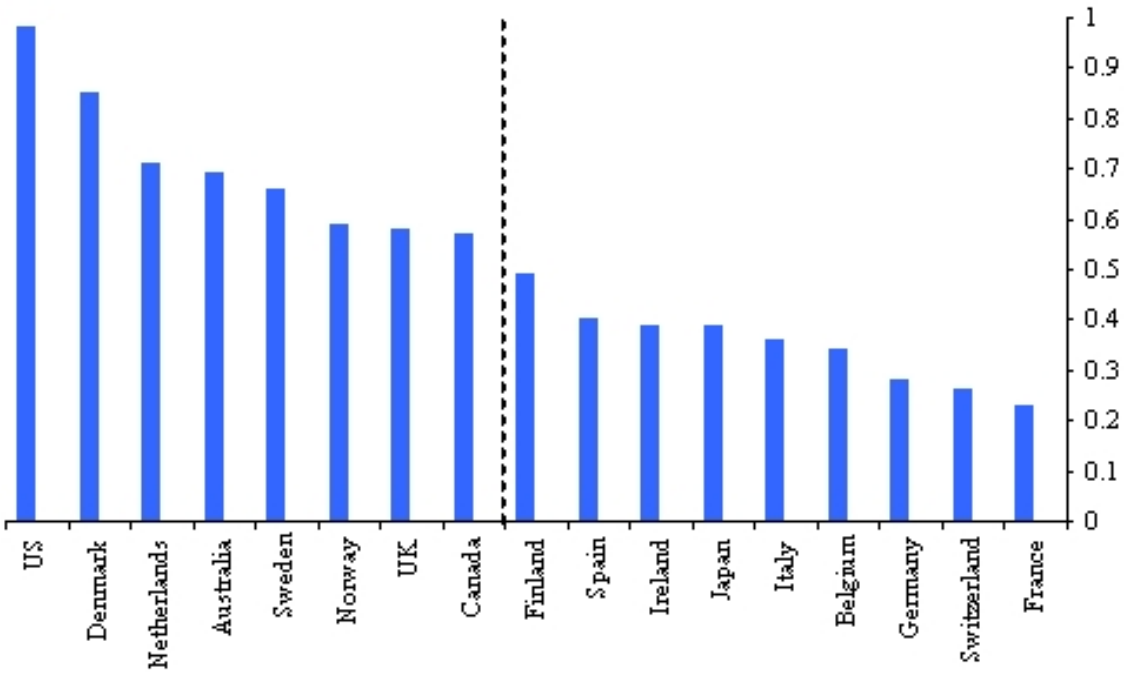

Figure 2: IMF (2008) Index of Mortgage Market Development

$A_{LDM,k} = A_k + mor_{LDM,k}$ for $k = 1, ..., L$ as the responses in a typical country with a more developed market and in a typical country with a less developed market.

3.1.3 Securitization and Time-varying Financial Structure

A major development in mortgage finance in the past twenty five years has been the increased availability of mortgage-backed securities (MBS) through changes in legislation in a number of countries. Hoffmann and Nitschka (2009) construct a qualitative *de jure* indicator for the degree securitization in the mortgage sector.[9] To exploit this variation we apply the interacted Panel VAR approach of Towbin and Weber (2010) and augment the VAR with an interaction term. To estimate the effect of securitization on the transmission mechanism and we generalize our model to:

[9] We would expect the degree of securitization to be endogenous to developments in the housing market. When the housing market is booming the probability of mortgage default is low and there is high demand for MBS. When the housing market is in a recession, borrowers' default probabilities increase and become correlated and MBS lose liquidity as a result. Because the Hoffman and Nitschka is a *de jure* indicator it reflects insitutional changes in the ability to securitize assets and is not likely to suffer from endogeneity.

$$Y_{i,t} = A_{i,0} + B_{i,0}MBS_{i,t} + \sum_{k=1}^{L} A_{i,k}Y_{i,t-k} + u_t \quad t = 1, ...T \;\; i = 1, ..., N \;\; u_{i,t} \tilde{} N(0, \Sigma)$$

where $A_{it,k} = A_k + B_k MBS_{i,t} + \varepsilon_{i,k}$ and $MBS_{i,t}$ stands for the securitization index. We can then compute impulse responses for a typical country with a high degree of securitization and coefficient matrix $A_{HMBS,k} = A_k + B_k MBS_{HIGH}$ and a typical country with a low degree of securitization and coefficient matrix $A_{LMBS,k} = A_k + B_k MBS_{LOW}$. Apart from its effect on the dynamics, securitization may also have a permanent effect on the level of variables. To control for such an effect, we include the index also in levels.

The index equals one if countries have a fully liberalized MBS market and zero if no securitization is allowed. If a limited degree of securitization is allowed the index takes the value 0.3. The data is at quarterly frequency and covers the period from 1985 to 2008 Q1. In the United States mortgage-backed securities have been allowed during the whole sample period. In Australia, Canada, Netherlands, Spain and the United Kingdom they have become widely available after major mortgage market reforms during the sample period. Whereas a limited form of securitization has existed in Switzerland, Germany, and Sweden for a long time, liberalisation has led to an intermediate degree of securitization in Finland and France. In Denmark, Italy, Japan, Belgium, and Norway securitization has not been introduced.[10]

If securitization affects the transmission of monetary policy shocks and capital inflows shocks, we expect variation of the VAR coefficients over time.

3.2 Identification

We identify two types of shocks that lead to lower domestic interest rates: an expansionary monetary policy shock and a capital inflows shock. The two shocks are identified using the sign restrictions approach developed by Canova and de Nicoló (2002), Faust and Rogers (2003), and Uhlig (2005).

We can think of the one step ahead prediction error u_t as a linear combination of orthonormal structural shocks $u_t = Bv_t$, with $E(v_t'v_t) = I$. The only restriction on B comes from the covariance matrix of the prediction errors $\Sigma = E(u_t u_t') = E(Bv_t v_t' B') = BB'$. This leaves many degrees of freedom in specifying B and further restrictions are necessary to achieve identification. The challenge for structural VAR models is to find credible restrictions on B. Sign restrictions narrow down the set of acceptable B by restricting the sign of the impulse responses of a set of variables to a structural shock.

The sign restrictions used to identify capital inflows and monetary policy shocks are similar as in Sá and Wieladek (2010) and rely on previous theoretical and empirical work. We do not impose any restrictions on the housing variables, which are our main variables

[10] Data for Ireland and New Zealand is missing.

of interest. Following Uhlig (2005), we impose the sign restrictions for four quarters after the shock for all variables. Table 1 lists the sign restrictions we have used for identification.

Positive capital inflows shocks lead to an increase in the current account deficit, a decrease in the long term interest rate, and an appreciation of the real exchange rate. The restriction are consistent with the regularities of capital inflow periods identified by Reinhart and Reinhart (2008). We understand a capital inflows shock to be an unexpected increase in foreigners' demand for domestic assets. Open economy models can deliver a number of reasons for foreigners' increase in demand for domestic assets. For example, a global increase in savings would increase demand for assets in general and therefore also lower the domestic ex ante real interest rate. Domestic residents dissave and consume more, leading to a real exchange rate appreciation and a current account deficit. Another possibility is a reshuffling of foreigners' portfolios towards domestic assets (Sá and Viani, 2010; Caballero et al., 2008). Such a shift may happen both of changes in the foreign portfolio preferences, foreign financial market structure or a domestic financial reform, all of which make it more attractive for foreigners to invest in domestic assets. Again, the portfolio shift towards domestic assets leads to a capital inflow, lower real domestic interest rates and an appreciation of the exchange rate. Finally, foreign monetary authorities may attempt to improve competitiveness through expansionary monetary policy. Low foreign interest rates make domestic assets more attractive, capital inflows drive down the domestic real interest rate, and the real exchange rate appreciates. Although the sources of these events are quite distinct, we argue that the consequences for the domestic economy and in particular the housing sector should be similar. In all cases lower domestic real interest rates should lead to an expansion in domestic credit and spur housing activity. Therefore, we impose that positive capital inflows shocks lead to an increase in the current account deficit, a reduction in long term interest rate, and an appreciation of the real exchange rate.

We restrict the real long term rate rather than the nominal rate, because real shifts in the total demand for domestic assets should affect real returns. The restriction is on the long rate as opposed to the short rate because a broad class of models assumes that the central bank perfectly controls the short rate. Our measure for expected inflation is the VAR forecast. We implement the restriction by computing the response of the nominal long rate and the price level in a first step. We then use the response of the price level to compute the response of the (annualized) ten year inflation and subtract the inflation response from the response of the nominal long term rate to compute the response of the ex ante real rate.[11]

Our assumption regarding the behaviour of the long term interest rate is crucial to distinguish capital inflows shocks from other shocks that generate a real appreciation and a current account deficit. Consider a small open economy with nontraded goods and imperfect substitutability between domestic and foreign assets. An aggregate demand shock

[11] Restricting the response of the nominal or the short term interest rate yields very similar results.

(public or private) would lead to a real appreciation (because of higher demand for non-traded goods) and a current account deficit, but to an increase in the real interest rate. Without the restriction on the long rate, these two shocks would be observationally equivalent to a capital inflows shock. In standard models transitory productivity shocks generate a current account surplus, because people save a large fraction of their temporary income increase. The current account behavior is inconsistent with our sign restrictions. However, a permanent increase in the total factor productivity will lead to a current account deficit. It increases the marginal productivity of capital which makes investing in the domestic economy more attractive and, since the increase is permanent and the consumption smoothing motive disappears, savings will not rise. Capital flows in and the exchange rate appreciates, consistent with our sign restrictions. It leads, however, to an increase in the domestic real interest rate because of the increase in the marginal productivity of capital and imperfect substitutability of assets impedes exact interest rate parity.[12]

Identification of monetary policy shocks relies on a large literature surveyed in Christiano, Eichenbaum and Evans (1999). An expansionary monetary policy shock decreases the nominal short rate, leads to an increase in prices and output and to a real depreciation. This is consistent with the sign restrictions derived theoretically in Canova and de Nicoló (2002). They show that, under a variety of different models, output and prices rise following an expansionary monetary policy shock. The restrictions on the exchange rate follows from a simple Mundell Fleming model. Lower interest rates decrease the demand for domestic financial assets and involve a depreciation of the nominal and, in a sticky price environment, the real exchange rate. The model's prediction follows from uncovered interest rate parity, for which empirical support is limited. Our restriction is, however, only on the sign of the exchange rate movement, not the exact quantitative extent. There is broad empirical support that the exchange rate depreciates after an expansionary monetary policy shock. (see e.g. Eichenbaum and Evans,1995, Forni and Gambetti, 2010, Scholl and Uhlig, 2008, Zettelmeyer, 2004). [13]

A common alternative to sign restrictions is the Choleski decomposition, which assumes a lower triangular structure for B. This corresponds to imposing zero restrictions on the contemporaneous interactions between variables. To identify a monetary policy shock the set of explanatory variables must be split into a group of variables that do not respond contemporaneously to the short term interest rate but to which the short rate reacts to, and

[12] It is theoretically possible that the central bank cuts the nominal rate aggressively to fight the deflationary pressures that arise from the increase in productivity. This can also lead to a fall in the real rate, at least at shorter horizons. In that case, however, a permanent productivity shock will still have a permanent effect on the real exchange rate. Our empirical results indicate no permanent effect on the real exchange rate, which is inconsistent with a permanent productivity shock.

[13] An unresolved issue is whether "delayed overshooting" occurs. Eichenbaum and Evans (1995) and Scholl and Uhlig (2008) find that the exchange rate continues to depreciate for a few periods after the monetary policy shock, which is in contradiction to Dornbusch's (1976) overshooting model. Forni and Gambetti (2010) use structural dynamic factor models and show that delayed overshooting disappears once a sufficient amount of economic information is included in the model.

	Capital Inflows Shock	Monetary Policy Shock
Short term nominal interest rate		-
Long term real interest rate	-	
Real Exchange Rate	+	-
Current Account	-	
Consumer Price Index		+
Output		+

Table 1: Sign Restrictions

a group of variables that react contemporaneously to changes in the short rate, but have no immediate effect on the short rate. A number of studies use the Choleski decomposition to analyze the effect of monetary policy shocks on the housing sector (see Assenmacher-Wesche and Gerlach, 2010 and Calza, Monacelli, and Straca, 2009). A Choleski decomposition often forces researchers to impose more zero restrictions on contemporaneous relations than delivered by theory. The ordering of asset prices and credit with respect to the short term interest rate is especially problematic. Sign restrictions provide a means to check the robustness of these studies by using less restrictive identification assumptions.

3.3 Inference

Following Uhlig (2005) we compute Bayesian error bands. Our error bands capture two types of uncertainty: parameter uncertainty and identification uncertainty. Uncertainty about the true parameters $A_{i,k}$ and Σ follows from a limited number of observations and appears in all SVAR models. For SVARs that use exact short or long run restrictions there is no identification uncertainty: given Σ and $A_{i,k}$, there is a unique B that will satisfy the identification restrictions. With sign restrictions there is a set of B matrices that satisfy the sign restrictions. Identification is inexact and the there is additional uncertainty about the correct identification scheme. Using a similar approach as Paustian (2007), we propose to separate identification and parameter uncertainty.

To account for parameter uncertainty we use an uninformative Normal-Wishart prior. We draw all parameters jointly from the posterior (including the coefficients on the interaction terms). Given a parameter draw d, we then evaluate the coefficient for the country type we are interested in. For example, for a country with high prevalence of mortgage-backed securities we compute $A^d_{HMBS,k} = A^d_k + B^d_k MBS_{HIGH}$, given draws A^d_k and B^d_k. As in Cogley and Sargent (2005) we impose the prior that responses are not explosive and discard explosive draws.

For a given parameter draw, we then account for identification uncertainty and compute the set of B matrices that satisfies the sign restrictions. Let $\tilde{B}_d$ be an orthogonal factorization, e.g. the Choleski decomposition, of the posterior draw of the covariance matrix Σ_d,

with $\tilde{B}_d\tilde{B}_d' = \Sigma_d$. Multiplying $\tilde{B}_d$ with orthonormal matrix Q , $B_d = Q\tilde{B}_d$ will generate another decomposition of $\Sigma_d : B_dB_d' = \tilde{B}_dQ\ Q'\tilde{B}_d'$. Following Rubio-Ramirez, Waggoner, and Zha (2009) we compute Q by drawing an independent standard normal $q \times q$ matrix X and apply the QR decomposition $X = QR$. We keep the draw if B_d generates impulse responses that satisfy the sign restrictions for both shocks. For a given parameter draw, we repeatedly draw Q until we have found 100 matrices that satisfy the sign restrictions. We save the point wise median and 16% and 84% percentiles of the impulse response distribution generated by accepted matrices B_d.

We repeat this exercise for 100 parameter draws and save median, upper, and lower percentile for each parameter draw. This gives us 100 different estimates of the median, the lower, and the upper percentile. The first statistic focuses on the distribution of all medians. We report the median of all medians and, as error bands, the 16th and 84th percentile of the distribution. In this case the error bands account for parameter uncertainty and reflect the uncertainty about the true median that comes from limited sample size. As a second statistic we report the median of the lower and upper percentile across all parameter draws. In this case the error bands reflect identification uncertainty.

In comparison to our approach, error bands reported in Uhlig (2005) reflect both parameter and identification uncertainty. Separating identification and parameter uncertainty can provide useful additional information. The type of uncertainty that should be taken under consideration in constructing error bands depends on the question being asked. If the question is whether we can confidently say that the response of house prices to a capital inflows shocks is positive, we should account for both parameter and identification uncertainty. We have to consider both the fact that we have only a limited amount of data (which leads to parameter uncertainty) and limited information on the properties of the structural shocks (which leads to identification uncertainty). But if the question is whether impulse responses differ between countries with high and low mortgage market development, we should focus on parameter uncertainty. This is because structural mortgage market differences between the two types of countries will be reflected in differences in parameters rather than identification. The confidence with which we can say that the distribution of medians differs between the two countries depends on how precise the estimates are (which relates to parameter uncertainty). If we compare medians for two types of countries, we account for potential correlation between the median estimates and compute the medians with the same parameter draws.[14]

To ensure the comparability of impulse responses we normalize the size of a shock to

[14]Uhlig (2005) proposes as an alternative to the pure sign restriction approach where error bands only reflect parameter uncertainty. The approach chooses the orthogonal factorization that minimizes a penalty function that penalizes wrong sign and rewards correct signs of impulse responses. To identify a unique decomposition the penalty function rewards strong responses with the correct sign more than weak responses with the correct sign. A disadvantage is that we lose the information about identification uncertainty and the choice of the penalty function is arbitrary. The reward of strong responses also tends to make the selected responses larger than the median.

one standard deviation, based on a covariance matrix estimate of the whole sample. For our case, normalizing with respect to the size shock seems preferable to normalizing with respect to the response of a given variable. While for monetary policy shocks normalizing with respect to the short term interest rate may seem natural (for example, a fall by 25 basis points), the choice of a variable to normalize a capital inflows shock it is not obvious. Standardizing with respect to the probability of the event (under normality a one standard deviation shock implies that in 68% of the cases events are smaller in absolute size) will also facilitate the comparison of capital inflows and monetary policy shocks and across different mortgage market structures.

4 Results

4.1 The Effects of Capital Inflows and Monetary Policy Shocks on Housing Variables

Figures 3 and 4 show the impulse response functions over 40 quarters for a one standard deviation capital inflows and monetary policy shock. We plot the median (solid, blue) and the 16% and 84% error bands that account for parameter uncertainty (dashed, red) and identification uncertainty (dotted, black). The grey shaded area indicates the variables and the horizon for which we impose sign restrictions.

At the median a capital inflows shock leads on impact to a current account deficit of about 0.3% of GDP, the long rate falls by about 13 basis points and the real effective exchange rate appreciates by about 1%. A capital inflows shock leads to an expansion of the housing sector. There is a persistent rise in real private credit and house prices that in both cases peak after ten quarters at about 0.4%, before slowly reverting back to zero. The response of residential investment is quicker and more short lived, peaking at 0.6% after two quarters. Error bands indicate that the responses for all housing sector variables are statistically significant. The price level initially falls by about 0.1% before beginning to rise after about a year. The deflationary pressures may arise either because a nominal appreciation lowers the domestic currency prices of imports or as a result of an inflow of cheap imports. Output rises only moderately. The median response peaks at 0.1% after ten quarters and error bands reflect considerable identification uncertainty on the exact extent. The nominal short rate falls by about the same as the long rate, keeping the term spread initially constant. The short rate then start to rise and peaks at 5 basis points after twelve quarters. The shape of the response is consistent with a central bank that reacts to the fall in prices by lowering policy interest rates and then starts raising them again as inflation resumes. If we assume that central banks do not have full control over the short rate, an alternative explanation is that capital inflows affect the term structure at all maturities by about an equal amount.

A monetary policy shock leads to a fall in the short rate by 30 basis points. The long rate falls by only 10 basis points and the term spread therefore rises. We observe a per-

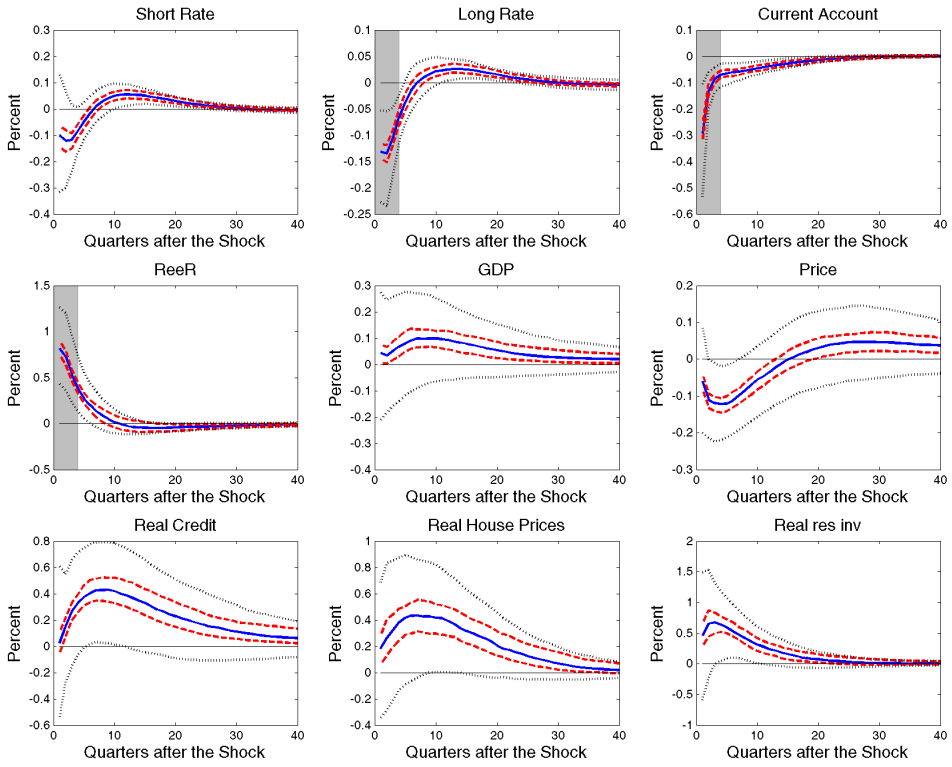

Figure 3: Impulse Responses for Capital Inflows Shock

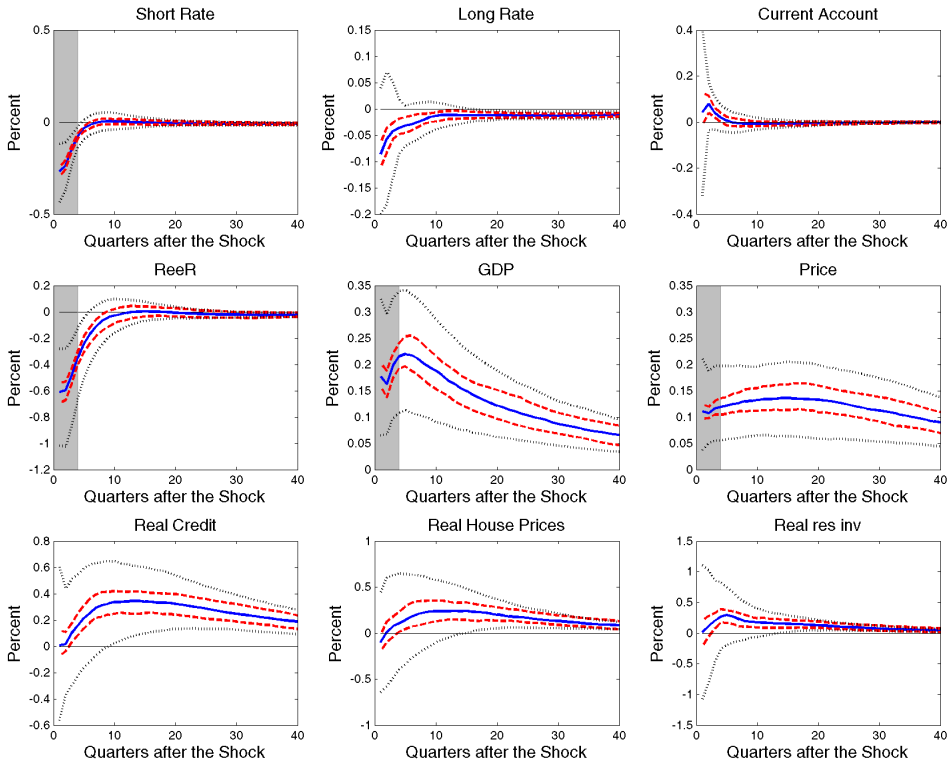

Figure 4: Impulse Responses for Monetary Policy Shock

	Monetary Policy Shock			Capital Inflows Shock		
	1 year	3 years	10 years	1 year	3 years	10 years
Baseline						
real credit	4.87	6.23	8.25	5.72	8.68	8.04
real house prices	4.30	4.27	5.75	5.41	7.43	8.26
residential investment	4.58	5.12	5.64	7.24	9.39	9.12
IMF Index high						
real credit	5.02	7.56	10.80	5.55	7.77	7.02
real house prices	5.08	5.32	6.10	6.61	8.80	7.88
residential investment	5.31	5.24	5.51	7.72	9.15	8.58
IMF Index low						
real credit	4.35	4.56	5.70	5.63	7.44	7.48
real house prices	4.41	4.85	5.85	4.67	5.53	5.95
residential investment	3.99	5.00	5.77	5.75	7.13	7.17
MBS Index high						
real credit	5.91	3.80	3.28	6.26	13.72	17.49
real house prices	5.96	4.64	3.91	5.08	7.90	15.06
residential investment	5.16	4.13	4.51	6.66	12.53	14.72
MBS Index low						
real credit	4.56	6.53	8.51	5.05	6.44	6.32
real house prices	4.51	5.00	5.71	5.05	5.94	6.08
residential investment	4.83	5.71	5.82	6.34	7.74	7.57

Table 2: Variance Decomposition

manent increase in the price level of about 0.1%. Output rises to about 0.2% above trend after five quarters and falls slowly back to its long term value. The hump shaped response of output and its timing are consistent with previous studies that document the effects of monetary policy shocks in VARs.[15] The real exchange rate depreciates initially by about 0.5% and then appreciates slowly back to its long run value, as Dornbusch's overshooting model predicts. At the median the current account improves slightly, consistent with the competitive effects of a weak exchange rate, but there is substantial identification uncertainty. The shape of the housing variables' responses is similar to the capital inflows shock, but the size of the response is smaller. Real credit and house prices peak at about 0.3% and 0.2% after ten quarters. Real residential investment reacts quickly and peaks at 0.25% after three quarters. For all three housing variables, zero lies outside the identification uncertainty error bands at some point, but at short horizons the bands are wide.

Table 2 shows the forecast error variance decomposition. At the median capital inflows

[15]See Christiano, Eichenbaum and Evans (1998) for a survey.

shocks seem to be able to explain up to 8%, 8% and 9% of the variance of real credit, house prices and residential investment at longer forecast horizons. Monetary policy shocks on the other hand explain up to 8%, 6% and 6%. This is in contrast to the results presented in Sá and Wieladek (2010). They find that for the United States capital inflows explain a substantially larger fraction of the variance in house prices than monetary policy shocks. The difference could arise from the large sample of countries we consider here and differences in their mortgage structures.

4.2 The Role of Cross-Sectional Variation in Mortgage Market Development

We use the index in IMF (2008) to split countries into two groups: a group with more developed and one with less developed mortgage markets. Figures 5 and 6 compare median impulse responses of housing variables for the two groups. Error bands reflect parameter uncertainty. Mortgage market development affects the transmission of monetary policy shocks: in a highly developed mortgage market, the rise in real residential investment peaks at about 0.5%, whereas the response in a low developed market is approximately zero. Real house prices increase by almost 0.4% after ten quarters in a more developed market, compared to a very muted response in a less developed market. The peak response of real private credit in a highly developed market at 0.4% is about double that of the response in a less developed one. The differences are statistically significant for all three variables. Capital inflows shocks also have a greater effect on housing market variables in countries with higher mortgage market development, but the difference is less pronounced. While the response of real house prices is clearly stronger, the difference in real residential investment, although positive, is only marginally significant. There appears to be no difference in the response of real private credit. Table 2 shows that share of the forecast error variance of the three housing variables that can be explained by monetary and capital inflows shocks tends to be slightly higher in countries with a more deregulated mortgage market.

Our results indicate that capital flows and monetary policy shocks have a stronger effect on housing variables in more developed mortgage markets and are consistent with a role for the "financial accelerator". In highly developed mortgage markets households can pledge a larger fraction of their house as collateral, which results in higher leverage. If households are highly indebted, they are more sensitive to changes in interest rates, because small changes in rates can have a large effect on their ability to serve the debt. As a result, housing demand becomes more sensitive to interest rates.

4.3 The Role of Securitization and Time-varying Financial Structure

Figures 7 and 8 compare the impulse responses of housing variables in countries with a high and a low prevalence of mortgage-backed securities. We evaluate the reduced form coefficients at values $MBS_{HIGH} = 0.75$ and $MBS_{LOW} = 0.25$ and report the median

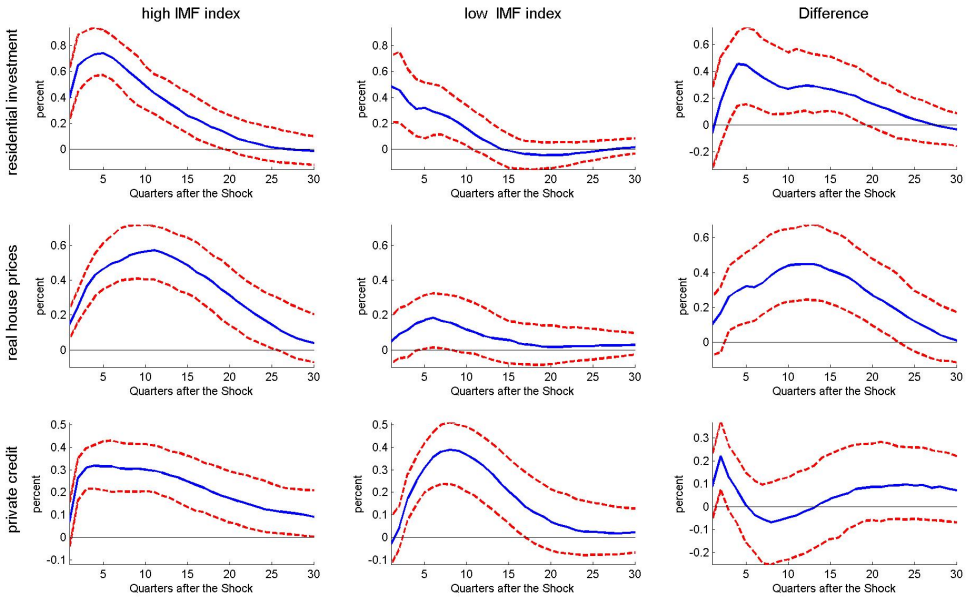

Figure 5: The Role of Mortgage Market Development: Capital Inflows Shock

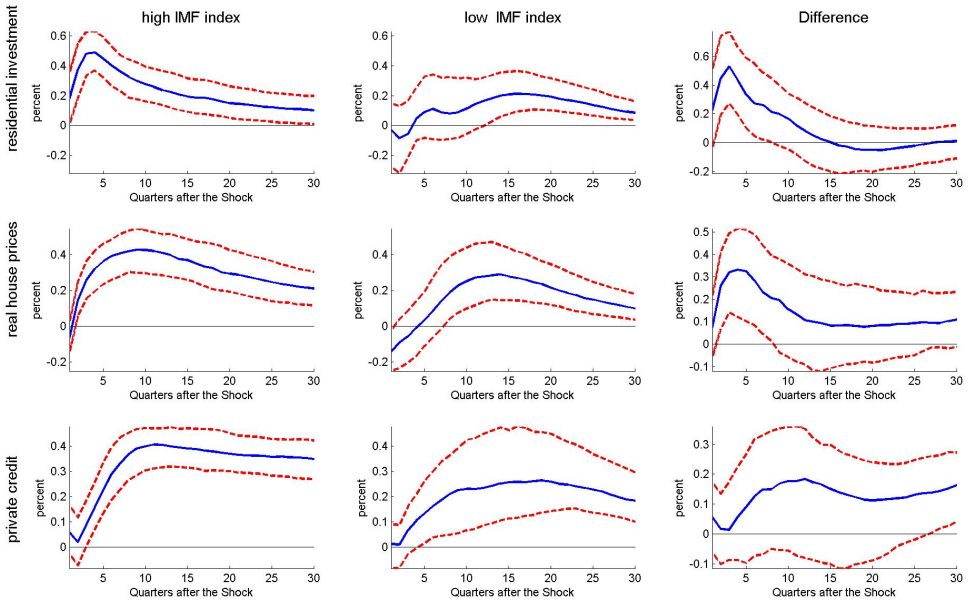

Figure 6: The Role of Mortgage Market Development: Monetary Policy Shock

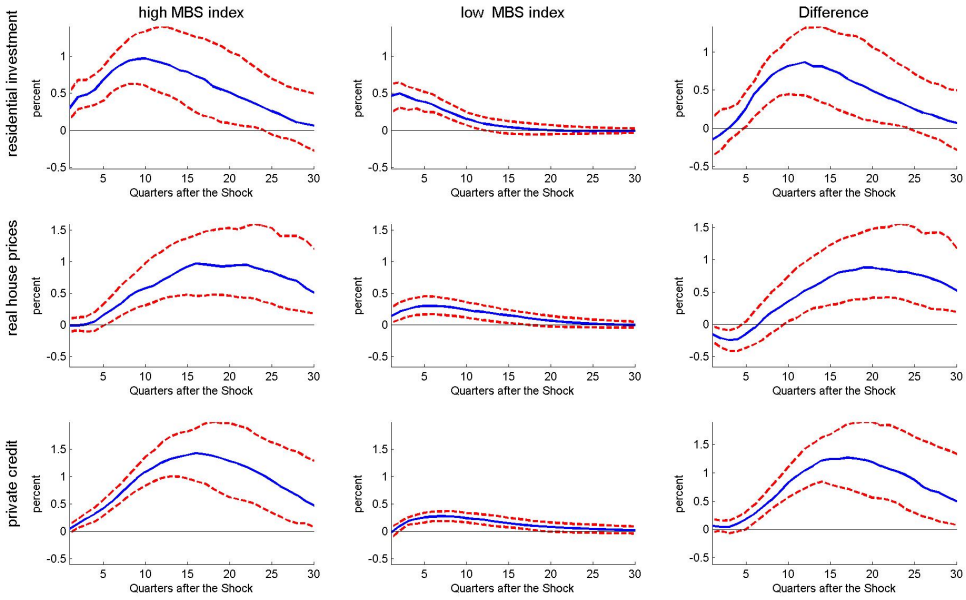

Figure 7: The Role of Securitization: Capital Inflows Shock

impulse response with error bands that account for parameter uncertainty. A high value of the index indicates that mortgage-backed securitization is permitted, while a low value indicates that securitization is restricted.

Capital inflows shocks have a larger and more persistent effect in countries that allow for mortgage-backed securities. In a country with a high MBS index the response of real private credit peaks at 1.4%, which is approximately five times stronger than in a country with a low MBS index. A high value of the MBS index also amplifies the responses of real residential investment and house prices, by a factor of about 2 and 3, respectively. The differences are statistically significant for all three variables. The amplifying effect of mortgage-backed securities is also reflected in the forecast error variance decomposition, reported in Table 2. Capital inflows shocks explain about 18% of the variation in real credit at the ten year horizon in countries with high levels of securitization, compared to about 6% in countries with low levels of securitization. For real house prices, the fraction is 15% in high securitization countries versus 6% in low securitization countries. For real residential investment the fraction is 15% versus 6%.

Securitization also amplifies monetary policy shocks, but to a smaller degree. In countries with a high MBS index the effect of monetary policy shocks on real residential investment peaks at 0.4% compared with 0.3% in countries with a low MBS index. The peak responses of house prices and credit are also about 0.1% higher in countries where

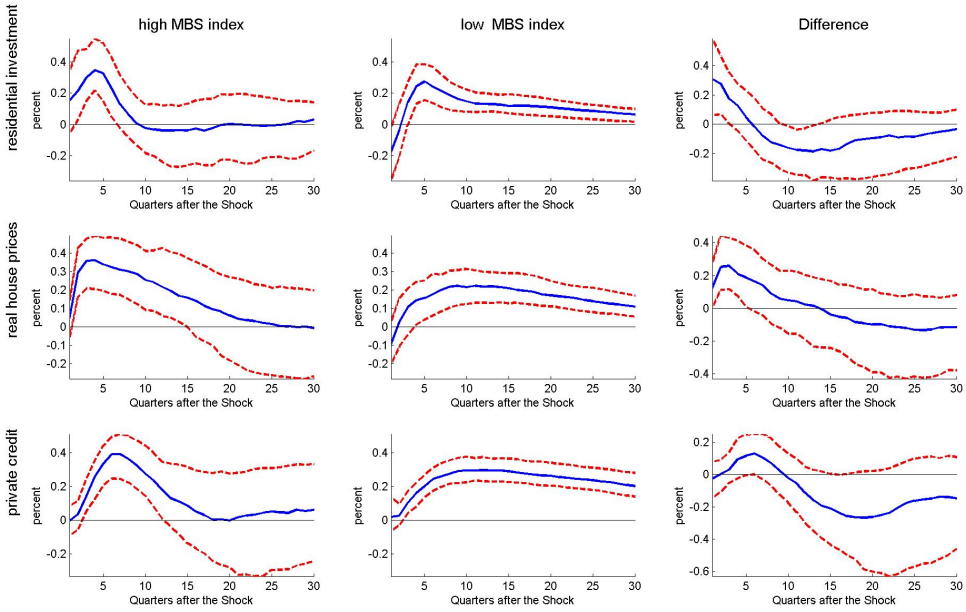

Figure 8: The Role of Securitization: Monetary Policy Shock

mortgage-backed securitization is more prevalent. The differences are marginally significant, but only for a short horizon. In terms of forecast error variance decompositions, reported in Table 2, there is no evidence that the contribution of monetary policy shocks is larger in countries that have mortgage-backed securities. The fraction of the variance in the housing variables explained by monetary policy shocks is even somewhat smaller in countries with high prevalence of MBS. In countries with high levels of securitization monetary policy shocks explain between three and five percent of the variation in credit, house prices and residential investment. This compares with fractions between 9% and 6% in low securitized countries. A possible explanation is that mortgage-backed securities amplify the contribution of other shocks, such as capital inflows shocks. As a result, the contribution of monetary policy shocks shrinks.

The finding that securitization amplifies the effects of both shocks is again consistent with the presence of a financial accelerator mechanism. If we assume that securitization increases the efficiency of the financial system and allows households to be more leveraged, the effect of interest rate changes on the housing market should increase. The results are also consistent with the argument of Rajan (2005) that securitization allowed banks to take more risk and financial intermediaries became more sensitive to interest rates. It does not automatically follow from these explanations why the amplification effect on capital inflows is much stronger. One explanation, put forward by Diamond and Rajan (2009)

is that securitization permits international investors to invest into mortgage debt directly. This could strengthen the effects of capital inflows on the domestic housing market.

5 Robustness

A major limitation with the index of mortgage market development constructed in IMF (2008) is its time-invariant nature. In Anglo-Saxon and Nordic countries deregulation of mortgage markets was relatively rapid and was completed by the mid-1980s. Because our sample starts in 1984, it would capture the period post mortgage market deregulation in these countries. However, in Japan and continental Europe the process was more gradual. To check whether our results are affected by these structural changes, we estimate the model restricting the time period to 1990Q1 - 2007Q2. Table 3 reports the responses in high and less developed mortgage at the one and three year horizon, together with 16th and 84th percentiles. For comparison, the results obtained before for the period 1984Q1 - 2007Q2 are also reported. The results for the restricted time period are qualitatively similar, but less precise, probably because of the smaller number of observations. As before, the responses of the housing variables to both shocks tend to be stronger in countries with a high degree of mortgage market development.

For further robustness, we also report results for three alternative sample splitting criteria: the ratio of mortgage debt to GDP listed in Calza et al. (2009), the possibility of mortgage equity withdrawal, and the typical loan to value ratio. Again, only time invariant, cross sectional information is available. The results, reported in Table 3 suggest that housing variables respond more strongly to both shocks in countries that have a higher mortgage to GDP ratio. In all cases the differences have the expected sign and in four out of six cases the difference is statistically significant at least at one of the horizons. In countries that allow for mortgage equity withdrawal all three housing variables respond more strongly to monetary policy and capital inflows shocks. Except for the response of private credit to a capital inflows shock, the difference is significant at the one or three year horizon. Splitting according to typical loan to value ratios, we detect significant differences in the responses of all three variables to monetary policy shocks, but not for capital inflows shocks.

6 Conclusion

In this study we examine several potential explanations for housing sector booms: monetary policy, capital inflows and financial innovation. We use a Panel VAR framework and identify monetary policy and capital inflows shocks with sign restrictions. To assess whether the structure of the mortgage market affects the transmission of macroeconomic shocks to the housing sector we split the sample into countries with high and low mortgage market development. We also adapt the model to allow the coefficients in the VAR to vary with

	High		Low		Difference	
	4 q	12 q	4 q	12 q	4 q	12 q
IMF Index						
Monetary Policy Shock						
pr cred.	0.18	0.37	0.10	0.21	0.07	0.15
	(0.07, 0.28)	(0.28, 0.45)	(-0.01, 0.19)	(0.05, 0.37)	(-0.04, 0.24)	(-0.04, 0.36)
house pr.	0.30	0.38	-0.02	0.28	0.32	0.09
	(0.21, 0.42)	(0.27, 0.50)	(-0.16, 0.13)	(0.13, 0.46)	(0.11, 0.50)	(-0.10, 0.27)
res. inv.	0.46	0.23	0.02	0.13	0.45	0.09
	(0.34, 0.60)	(0.13, 0.33)	(-0.15, 0.22)	(0.01, 0.35)	(0.18, 0.68)	(-0.12, 0.25)
Capital Inflows Shock						
pr cred.	0.33	0.28	0.24	0.31	0.08	-0.02
	(0.23, 0.42)	(0.19, 0.41)	(0.13, 0.38)	(0.14, 0.47)	(-0.06, 0.24)	(-0.18, 0.23)
house pr.	0.42	0.53	0.12	0.07	0.33	0.49
	(0.28, 0.59)	(0.39, 0.70)	(-0.06, 0.29)	(-0.07, 0.21)	(0.09, 0.51)	(0.26, 0.70)
res. inv.	0.77	0.39	0.32	0.07	0.47	0.32
	(0.59, 0.96)	(0.24, 0.58)	(0.10, 0.54)	(-0.09, 0.19)	(0.15, 0.76)	(0.12, 0.57)
IMF Index (since 1990)						
Monetary Policy Shock						
pr cred.	0.03	0.20	0.17	0.19	-0.11	0.01
	(-0.06, 0.14)	(0.10, 0.28)	(0.04, 0.31)	(0.02, 0.35)	(-0.31, 0.03)	(-0.17, 0.19)
house pr.	0.27	0.28	-0.02	0.25	0.28	0.03
	(0.14, 0.37)	(0.19, 0.38)	(-0.16, 0.14)	(0.14, 0.39)	(0.11, 0.46)	(-0.12, 0.19)
res. inv.	0.65	0.26	0.50	0.24	0.15	0.02
	(0.53, 0.81)	(0.14, 0.38)	(0.26, 0.76)	(0.05, 0.52)	(-0.17, 0.45)	(-0.24, 0.27)
Capital Inflows Shock						
pr cred.	0.32	0.18	0.09	0.22	0.23	-0.04
	(0.20, 0.44)	(0.08, 0.28)	(-0.01, 0.21)	(0.08, 0.37)	(0.07, 0.35)	(-0.21, 0.13)
house pr.	0.30	0.13	0.07	0.10	0.19	0.04
	(0.12, 0.44)	(0.04, 0.24)	(-0.03, 0.22)	(-0.01, 0.20)	(0.01, 0.36)	(-0.12, 0.20)
res. inv.	0.06	-0.01	0.13	0.12	-0.07	-0.12
	(-0.12, 0.27)	(-0.14, 0.10)	(-0.10, 0.40)	(-0.05, 0.25)	(-0.41, 0.24)	(-0.32, 0.09)
Mortgage Debt						
Monetary Policy Shock						
pr cred.	0.22	0.38	0.08	0.26	0.15	0.13
	(0.13, 0.31)	(0.31, 0.47)	(-0.05, 0.16)	(0.11, 0.37)	(0.01, 0.28)	(0.00, 0.30)
house pr.	0.25	0.42	0.01	0.24	0.26	0.20
	(0.11, 0.35)	(0.29, 0.57)	(-0.10, 0.18)	(0.08, 0.36)	(-0.01, 0.40)	(-0.03, 0.43)
res. inv.	0.31	0.27	0.09	0.18	0.23	0.11
	(0.13, 0.45)	(0.16, 0.39)	(-0.12, 0.27)	(0.03, 0.35)	(-0.01, 0.45)	(-0.10, 0.30)
Capital Inflows Shock						
pr cred.	0.33	0.43	0.24	0.20	0.09	0.26
	(0.23, 0.43)	(0.29, 0.59)	(0.13, 0.35)	(0.05, 0.32)	(-0.07, 0.27)	(0.06, 0.42)
house pr.	0.50	0.68	0.08	0.01	0.38	0.65
	(0.35, 0.63)	(0.51, 0.86)	(-0.06, 0.23)	(-0.10, 0.16)	(0.20, 0.60)	(0.47, 0.89)
res. inv.	0.84	0.48	0.30	-0.00	0.51	0.48
	(0.66, 0.97)	(0.35, 0.71)	(0.07, 0.57)	(-0.13, 0.14)	(0.21, 0.76)	(0.31, 0.77)
MEW						
Monetary Policy Shock						
pr cred.	0.21	0.43	0.09	0.21	0.12	0.22
	(0.08, 0.28)	(0.35, 0.51)	(-0.05, 0.18)	(0.03, 0.33)	(-0.03, 0.26)	(0.04, 0.42)
house pr.	0.30	0.46	-0.00	0.22	0.31	0.24
	(0.15, 0.41)	(0.32, 0.57)	(-0.13, 0.09)	(0.07, 0.36)	(0.15, 0.49)	(0.04, 0.43)
res. inv.	0.42	0.29	-0.01	0.16	0.42	0.14
	(0.24, 0.53)	(0.17, 0.40)	(-0.17, 0.25)	(0.02, 0.34)	(0.14, 0.64)	(-0.09, 0.29)
Capital Inflows Shock						
pr cred.	0.34	0.36	0.32	0.35	0.01	0.03
	(0.25, 0.42)	(0.24, 0.47)	(0.19, 0.45)	(0.20, 0.52)	(-0.16, 0.16)	(-0.23, 0.23)
house pr.	0.41	0.62	0.22	0.16	0.21	0.48
	(0.25, 0.59)	(0.48, 0.81)	(0.07, 0.38)	(0.02, 0.33)	(-0.01, 0.40)	(0.20, 0.70)
res. inv.	0.73	0.50	0.52	0.08	0.23	0.43
	(0.55, 0.93)	(0.36, 0.68)	(0.30, 0.73)	(-0.07, 0.26)	(-0.13, 0.53)	(0.23, 0.65)
Loan To Value						
Monetary Policy Shock						
pr cred.	0.16	0.40	0.12	0.25	0.04	0.15
	(0.06, 0.29)	(0.29, 0.53)	(0.01, 0.20)	(0.12, 0.34)	(-0.11, 0.20)	(-0.01, 0.33)
house pr.	0.42	0.45	-0.08	0.16	0.50	0.30
	(0.31, 0.54)	(0.30, 0.59)	(-0.22, 0.07)	(0.03, 0.27)	(0.30, 0.69)	(0.10, 0.53)
res. inv.	0.49	0.22	0.01	0.13	0.49	0.11
	(0.33, 0.65)	(0.13, 0.38)	(-0.16, 0.22)	(0.02, 0.29)	(0.19, 0.73)	(-0.09, 0.31)
Capital Inflows Shock						
pr cred.	0.33	0.35	0.31	0.31	0.03	0.07
	(0.22, 0.49)	(0.20, 0.58)	(0.18, 0.39)	(0.18, 0.43)	(-0.11, 0.23)	(-0.15, 0.33)
house pr.	0.20	0.48	0.30	0.27	-0.12	0.17
	(0.04, 0.38)	(0.26, 0.74)	(0.17, 0.44)	(0.15, 0.44)	(-0.31, 0.09)	(-0.17, 0.50)
res. inv.	0.56	0.34	0.59	0.18	-0.03	0.16
	(0.33, 0.79)	(0.13, 0.57)	(0.38, 0.77)	(0.05, 0.32)	(-0.34, 0.27)	(-0.08, 0.41)

Median of Medians reported. Values in brackets are the 16 the and 84th percentile of the distribution of medians and account for parameter uncertainty

Table 3: Mortgage Market Characteristics: Results for Different Splitting Criteria

the degree of securitization and the degree of banking sector regulation.

We find that both capital inflows and monetary policy shocks have a significant and positive effect on real house prices, real credit to the private sector and residential investment. Housing variables respond more strongly to both shocks in countries with a more developed mortgage market, where securitization is more prevalent and where the banking sector is more competitive and less regulated. This is consistent with the presence of a financial accelerator mechanism. In highly developed mortgage markets households can pledge a larger fraction of their house as collateral, which results in higher leverage. If households are highly indebted, they are more sensitive to changes in the value of collateral. We find that the propagation effect of securitization is stronger for capital inflows than for monetary policy shocks. The response of housing variables to capital inflows shocks is larger and longer lasting in countries where securitization is allowed. A potential explanation is that mortgage-backed securitization allows international investors to invest directly into domestic mortgage.

The run-up to the present crisis was characterized by a housing boom in most OECD countries. Our results suggest that capital inflows coupled with innovations in the mortgage market tend to have a greater effect on the housing sector. This implies that countries with more developed mortgage markets, a high degree of securitization and more competitive and less regulated banking sectors should be wary of large external imbalances and work towards their reduction. Nevertheless, more research is necessary in order to improve our understanding of the interaction between capital inflows and the housing market. With better organisation and more transparency in securitization markets, for example, the amplification effect may be reduced.

A Data Sources

	Database	Remarks
Current Account to GDP ratio	OECD	sa[a], Denmark: IFS, seasonally adjusted in Eviews using additive X12 filter
Consumer Price Index	OECD	sa
Real Gross Domestic Product	OECD	sa
Long term nominal interest rate	OECD	Germany: IFS
Short term nominal interest rate	OECD	Ireland, Sweden: IFS
Real Private Credit	IFS	Line 22d, deflated with GDP deflator, adjusted for level shifts[b]
Real Residential Investment	OECD	Gross fixed capital formation, housing, for Switzerland: Gross fixed capital formation, construction
Real House Prices	BIS	
Reel Effective Exchange Rate	BIS	
Commodity Price Index	BIS	
Gross Domestic Product Deflator	OECD	sa DEU: IFS

[a] seasonally adjusted

[b] As in Goodhart and Hoffmann (2008) we adjust for level shifts that occur because of redefinitions or reclassification by replacing the growth rate in the quarter where the shift occurs with median growth of the two quarter before and after the shift. Level shifts occur for the following countres at the following dates: AUS 1984q3,1984q4, 1988q4; BEL 1992q4; CAN 1981q1, 2001q4; CHE 1974q4, 1982q3; DEU 1990q2, 199q1; DNK 1991q1,2000q3; FRA 1978q1; ITA 1999q1, 1991q1; IRE 1970q2, 1995q1, 1982q4; JPN 1997q4, 2001q4; NLD 1988q4; NZL 1988q3

	High Develompent Groups	Low Development Group
Mortgage Debt to GDP ratio	Australia, Denmark, Ireland, Netherlands, New Zealand, Norway, Switzerland, United Kingdom, United States	Belgium, Canada, Finland, France, Germany, Italy, Japan, Spain, Sweden,
Mortgage Equity Withdrawal	Australia, Denmark, Finland, Netherlands, Norway, New Zealand, Sweden, United Kingdom, United States	Belgium, France, Germany, Spain, Switzerland, Ireland, Japan, Canada, Italy
Typical Loan to Value Ratio	Australia, Belgium, Denmark, Netherlands, Sweden, United Kingdom, United States	Canada, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, Norway, Spain, Switzerland

Table 4: Mortgage Market Development: Sample Splits

References

Aizenman, Joshua, and Yothin Jinjarak (2009) 'Current account patterns and national real estate markets.' *Journal of Urban Economics* 66(2), 75–89

Assenmacher-Wesche, Katrin, and Stefan Gerlach (2010) 'Financial structure and the impact of monetary policy on property prices.' Mimeo, University of Frankfurt

Bernanke, Ben, and Mark Gertler (1989) 'Agency costs, net worth, and business fluctuations.' *American Economic Review* 79(1), 14–31

Bernanke, Ben S. (2010) 'Monetary policy and the housing bubble.' Speech at the Annual Meeting of the American Economic Association, Atlanta, Georgia, 3 January

Bernanke, Ben S, and Mark Gertler (1995) 'Inside the black box: The credit channel of monetary policy transmission.' *Journal of Economic Perspectives* 9(4), 27–48

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist 'The financial accelerator in a quantitative business cycle framework.' In *Handbook of Macroeconomics,* ed. J. B. Taylor and M. Woodford

Borio, Claudio, and Haibin Zhu (2008) 'Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?' BIS Working Papers 268, Bank for International Settlements, December

Caballero, Ricardo J, Emmanuel Farhi, and Pierre-Olivier Gourinchas (2008) 'An equilibrium model of "global imbalances" and low interest rates.' *American Economic Review* 98(1), 358–93

Calvo, Guillermo A., Leonardo Leiderman, and Carmen M. Reinhart (1994) 'The capital inflows problem: Concepts and issues.' *Contemporary Economic Policy* 12(3), 54–66

Calza, Alessandro, Tommaso Monacelli, and Livio Stracca (2009) 'Housing finance and monetary policy.' Working Paper Series 1069, European Central Bank, July

Canova, Fabio (2007) *Methods for Applied Macroeconomic Research* (Princeton University Press)

Canova, Fabio, and Gianni De Nicolo (2002) 'Monetary disturbances matter for business fluctuations in the G-7.' *Journal of Monetary Economics* 49(6), 1131–1159

Carstensen, Kai, Oliver Hülsewig, and Timo Wollmershäuser (2009) 'Monetary policy transmission and house prices: European cross-country evidence.' Technical Report

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans (1999) 'Monetary policy shocks: What have we learned and to what end?' In *Handbook of Macroeconomics,* ed. J. B. Taylor and M. Woodford, vol. 1 of *Handbook of Macroeconomics* (Elsevier) chapter 2, pp. 65–148

Cogley, Timothy, and Thomas J. Sargent (2005) 'Drift and volatilities: Monetary policies and outcomes in the post WWII U.S.' *Review of Economic Dynamics* 8(2), 262–302

Diamond, Douglas W., and Raghuram G. Rajan (2009) 'The credit crisis: Conjectures about causes and remedies.' *American Economic Review* 99(2), 606–10

Dornbusch, Rudiger (1976) 'Expectations and exchange rate dynamics.' *Journal of Political Economy* 84(6), 1161–76

Eichenbaum, Martin, and Charles L Evans (1995) 'Some empirical evidence on the effects of shocks to monetary policy on exchange rates.' *The Quarterly Journal of Economics* 110(4), 975–1009

Faust, Jon, and John H. Rogers (2003) 'Monetary policy's role in exchange rate behavior.' *Journal of Monetary Economics* 50(7), 1403–1424

Forni, Mario, and Luca Gambetti (2010) 'The dynamic effects of monetary policy: A structural factor model approach.' *Journal of Monetary Economics* 57(2), 203 – 216

Goodhart, Charles, and Boris Hofmann (2008) 'House prices, money, credit, and the macroeconomy.' *Oxford Review of Economic Policy* 24(1), 180–205

Hoffmann, Mathias, and Thomas Nitschka (2009) 'Securitization of mortgage debt, asset prices and international risk sharing.' CESifo Working Paper Series, CESifo Group Munich

Hume, Michael, and Andrew Sentance (2009) 'The global credit boom: Challenges for macroeconomics and policy.' *Journal of International Money and Finance* 28(8), 1426–1461

Iacoviello, Matteo (2005) 'House prices, borrowing constraints, and monetary policy in the business cycle.' *American Economic Review* 95(3), 739–764

IMF (2008) 'The changing housing cycle and its implications for monetary policy.' *IMF World Economic Outlook (April 2008)* pp. 103–130

Mishkin, Frederic S. (2007) 'Housing and the monetary transmission mechanism.' NBER Working Papers 13518, National Bureau of Economic Research, Inc, October

Paustian, Matthias (2007) 'Assessing sign restrictions.' *The B.E. Journal of Macroeconomics (Topics)*

Pesaran, M. Hashem, and Ron Smith (1995) 'Estimating long-run relationships from dynamic heterogeneous panels.' *Journal of Econometrics* 68(1), 79–113

Rajan, Raghuram G. (2005) 'Has financial development made the world riskier?' NBER Working Papers 11728, National Bureau of Economic Research, Inc, November

Reinhart, Carmen M., and Vincent R. Reinhart (2008) 'Capital flow bonanzas: An encompassing view of the past and present.' NBER Working Papers 14321, National Bureau of Economic Research, Inc, September

Rubio-Ramirez, Juan F., Daniel F. Waggoner, and Tao Zha (2010) 'Structural vector autoregressions: Theory of identification and algorithms for inference.' *Review of Economic Studies* 77(2), 665–696

Sá, Filipa, and Francesca Viani 'Shifts in portfolio preferences of foreign investors: an application to sovereign wealth funds.' University of Cambridge, Mimeo

Sá, Filipa, and Tomasz Wieladek (2010) 'Monetary policy, capital inflows and the us housing bubble.' Bank of England Working Paper. forthcoming

Scholl, Almuth, and Harald Uhlig (2008) 'New evidence on the puzzles: Results from agnostic identification on monetary policy and exchange rates.' *Journal of International Economics* 76(1), 1–13

Sims, Christopher A. (1988) 'Bayesian skepticism on unit root econometrics.' *Journal of Economic Dynamics and Control* 12(2-3), 463–474

Taylor, John B. (2009) 'The financial crisis and the policy responses: An empirical analysis of what went wrong.' NBER Working Papers 14631, National Bureau of Economic Research, Inc, January

Towbin, Pascal, and Sebastian Weber (2010) 'Limits of floats - the role of foreign currency debt and import structure.' HEID Working Papers 01-2010, Graduate Institute of International and Development Studies, Geneva

Uhlig, Harald (2005) 'What are the effects of monetary policy on output? results from an agnostic identification procedure.' *Journal of Monetary Economics* 52(2), 381–419

Warnock, Francis E., and Veronica Warnock (2009) 'International capital flows and u.s. interest rates.' *Journal of International Money and Finance* 28(6), 903 – 919

Zettelmeyer, Jeromin (2004) 'The impact of monetary policy on the exchange rate: evidence from three small open economies.' *Journal of Monetary Economics* 51(3), 635–652