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

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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.

Keywords: Capital Inflows, Monetary Policy, Housing, Mortgage Market Liberalization, Panel VAR

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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, 2008). 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 securitisation 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 securitisation, 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? To answer this question, we assess the effects of capital inflows, monetary policy and financial innovation on the housing sector.

The first contribution of this study 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. 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. There are a number of recent studies (Assenmacher-Wesche and Gerlach 2009; Carstensen et al. 2009, Calza et al., 2009, Goodhart and Hoffmann, 2008) that use structural VARs to analyze the transmission of monetary policy shocks to housing variables in advanced economies. The general conclusion is that a loosening in monetary policy increases housing activity. We extend this literature by comparing the effects of monetary policy to the effects of capital inflows. While there is a substantial literature that deals with the "capital inflows problem" and its implication for asset prices in developing economies (see e.g. Reinhart and Reinhart, 2008), studies on this link in developed economies are rare. 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. Figure 1 confirms this result for our sample of OECD countries. This suggests the presence of an important link between the current account balance and the housing sector, but the direction of causality is unclear. Using a VAR approach Sá and Wieladek (2010) find that capital inflows shocks explain a substantial

amount of real house price and residential investment variation in the United States. This study explores whether this pattern is present in a broader sample of countries.

Our second contribution is to explore how the structure of the mortgage market and legislation of mortgage securitisation affect the transmission of the two shocks. Following previous work, we estimate our Panel VAR across two subsamples of countries, split by their degree of mortgage market development. In addition, we also interact all of our Panel VAR coefficients with a time-varying index of mortgage market securitisation. Both procedures permit us to asses the effect of heterogeneity in the mortgage market structure on the transmission of shocks to the housing market. The effect of mortgage market characteristics will depend on the importance of the various transmission channels in place. Mishkin (2007) and Bernanke and Gertler (1995) survey the literature on potential transmission channels between interest rates and housing activity. 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, these transmission channels are amplified through a "financial accelerator" effect (Bernanke and Gertler,1995; Iacoviello, 2005; Calza et al., 2009). Households can only borrow against collateral and the amount they can borrow depends on the value of the collateral. A reduction in interest rates increases house prices and raises the value of the collateral. This increases borrowers' debt capacity and consequently the demand for houses even more. Borio and Zhu (2008) and Rajan (2005) propose an additional channel through which monetary policy may affect house prices — the "risk taking channel". According to this theory, low interest rates lead 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.

Mortgage market liberalisation may strengthen the "financial accelerator" mechanism and amplify the effects of interest rate shocks on the housing sector. For example, financial liberalisation increases competition between banks and allows households to borrow a larger amount for a given value of collateral. Therefore, a reduction in interest rates will lead to a larger increase in credit and house prices in countries with more liberalized financial markets. This appears to be consistent with empirical evidence. Calza et al. (2009) find that higher mortgage market development amplifies the effects of monetary policy shocks on housing variables. Assenmacher-Wesche and Gerlach (2009) also find role for mortgage market development, but argue that the effect is small. Both studies estimate Panel-VARs across two groups of countries, classified according to their degree of mortgage market development. The comparison of impulse responses across groups permits them to study whether mortgage market development affects the transmission mechanism of macroeconomic shocks. Our approach is similar to theirs but differs in two 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 monetary policy

shocks.[1] We find that both shocks have a larger effect in countries with a more developed mortgage market.

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. We argue that, in our sample period (from 1984 to 2007), this assumption seems reasonable for most features of the mortgage market. There is, however, substantial heterogeneity in the timing and type of legislation that regulates the issuance of mortgage-backed securities over the past 25 years. Diamond and Rajan (2009) argue that securitisation plays an important role in the transmission of interest rate shocks to the housing market.

Using a similar approach as Towbin and Weber (2010), we propose an interacted Panel VAR as a framework to exploit the time variation in the MBS index. By interacting all variables with an index of mortgage-backed securitisation, we allow the responses to vary with the degree of securitisation. Securitisation tends to amplify both types of shocks. But this amplification effect appears to be larger for capital inflows shocks. This result is consistent with the idea that mortgage-backed securitisation allows international investors to lend more directly to domestic households (Diamond and Rajan, 2009).[2] The remainder of the paper proceeds as follows. Section 2 discusses the methods and data, Section 3 presents the results and Section 4 concludes.

2 Methodology

2.1 Empirical Model and Data

2.1.1 Baseline model

We estimate the following VAR model for a panel of eighteen OECD countries:[3]

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

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_t

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

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

[3] 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.

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.

The first seven variables contain information about the general state of the economy and help to identify monetary policy and capital inflows shocks. We include commodity prices because previous studies have shown that they are important to explain movements in the price level (Sims, 1992). 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. To capture several features of housing booms, 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.[4] 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 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 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 variation

[4] 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.

$\varepsilon_{i,k} = D_{i,k}$ We begin our empirical analysis by looking at the impulse responses implied by the estimated average coefficients.

2.1.2 Mortgage Market Development

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 Anglo-Saxon and Nordic countries rapidly liberalized their mortgage markets from the early 1980s, in Japan and continental Europe the process was more gradual and competition remains limited. 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 take out bigger mortgages to finance spending when the value of their houses increases), secondary mortgage markets exist, and mortgage contracts are predominantly long-term. Because of limited data availability and since most of these variables are related to institutional and regulatory features that change slowly over time, the index is time invariant and refers to the period from the mid 1980s to present. We use the mortgage index to split countries into two groups: one group with highly developed mortgage markets (HDM) and another with less developed mortgage markets (LDM).[5] 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.[6] 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 $A_{LDM,k} = A_k + mor_{LDM,k}$ 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.

[5] For Switzerland we use the value calculated by Assenmacher-Wesche and Gerlach (2009). Because the index is not available for New Zealand, it is excluded from the sample.

[6] We split the sample at the median value. Attributing the Finland (the country with the median value) to the highly developed group or excluding it from the sample does not affect our results.

2.1.3 Securitisation

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 securitisation in the mortgage sector. 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 securitisation on the transmission mechanism and we generalize our model to $A_{it,k} = A_k + B_k MBS_{i,t} + \varepsilon_{i,k}$, where $MBS_{i,t}$ stands for the securitisation index. We can then compute impulse responses for a typical country with a high degree of securitisation and coefficient matrix $A_{HMBS,k} = A_k + B_k MBS_{HIGH}$ and a typical country with a low degree of securitisation and coefficient matrix $A_{LMBS,k} = A_k + B_k MBS_{LOW}$.

The index equals one if countries have a fully liberalized MBS market and zero if no securitisation has occurred. For limited degrees of securitisation the index is 0.3. The data is quarterly and covers the period from 1985 to 2008 Q1. In the United States mortgage-backed securities have been available 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 securitisation has existed in Switzerland, Germany, and Sweden for a long time, liberalisation has led to an intermediate degree of securitisation in Finland and France. In Denmark, Italy, Japan, Belgium, and Norway securitisation has not been introduced.[7] If securitisation affects the transmission of monetary policy shocks and capital inflows shocks, we expect variation of the VAR coefficients over time.

2.2 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

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

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 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. 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 real domestic 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, 2009; Caballero et al., 2008). 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. We restrict the real long term rate rather than the nominal rate, because we assume that foreign investors care about 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. We implement restriction by first computing the response of the nominal long rate and the price level to the shock. We then us the response of the price level to compute the response of the (annualized) ten year inflation and subtract inflation response from the response of the nominal long term rate to compute the response of the ex ante real rate.[8]

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. A positive total factor productivity shock increases the marginal productivity of capital which makes investing in the domestic economy more attractive. 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.[9] Similarly, an

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

[9] Because of consumption smoothing, a temporary productivity shock will also increase savings and lower real rates. The statement above assumes that the effect on investment dominates. Even if this is not the case, we will observe a current account surplus, again not in line with our sign restrictions.

aggregate demand shock (public or private) would lead to a real appreciation (because of higher demand for nontraded 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.

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 theoretical prediction on the exchange rate is supported by a large body of empirical work (see e.g. Eichenbaum and Evans,1995, Forni and Gambetti, 2010, Scholl and Uhlig, 2008, Zettelmeyer, 2004). [10]

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 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, 2009 and Calza, Monacelli, and Straca, 2008). A Choleski decomposition often forces researchers to impose more zero restrictions on contemporaneous relations than delivered by theory. As acknowledged by Assenmacher-Wesche and Gerlach (2009) the ordering of house 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.

2.3 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

[10] 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.

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 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 follow Sims and Zha (1999) and assume that the posterior density of the regression coefficients and the covariance matrix belongs to the Normal-Whishart family. 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 $\Sigma_d : B_d B'_d = \tilde{B}_d Q\ Q' \tilde{B}'_d$. 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. While he draws the reduced form VAR parameters and Q jointly, we draw them sequentially. 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 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.[11]

3 Results

3.1 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 and the 16% and 84% error bands that account for parameter uncertainty (red) and identification uncertainty (green). 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 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 uncertainty on the exact extent. The nominal short rate falls by about the same as the long rate, keeping the term spread initially

[11] 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.

constant. It 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 permanent increase in the price level of about 0.1%. Output rises to about 0.2% above trend after five quarters and falls slowly back 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.[12] 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 very wide.

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

3.2 The role of mortgage market development

We use the IMF index to split countries into 2 groups: A group with a more developed and one with less developed mortgage markets. Figures 5 and 6 compare median impulse responses of housing variables in a country with a highly and a less developed mortgage market. 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 respond in 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 the less developed counterpart. The differences are

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

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 variation in 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.

The result of stronger responses in developed mortgage markets is consistent with a role for the financial accelerator effect. 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, risk premia and lending are more sensitive to changes in the risk-free rate, since small changes in the interest rate can have a large effect on their ability to serve the debt. As a result, housing demand becomes more sensitive to interest rates.

3.3 The role of securitisation

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 impulse response with error bands that account for parameter uncertainty. A high value of the index indicates that mortgage-backed securitisation is permitted, while a low value indicates that securitisation 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 amplifying effect of mortgage-backed securities is also reflected in the forecast error variance decomposition. The differences are significant for all three variables. Capital inflows shocks explain about 18% of the variation in real credit at the ten year horizon in countries with high levels of securitisation, compared to about 6% in countries with low levels of securitisation. For real house prices, the fraction is 15% in high securitisation countries versus 6% in low securitisation countries. For real residential investment the fraction is 15% versus 6%.

Securitisation 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 mortgage-backed securitisation is more prevalent. The differences are marginally signif-

icant, but only for a short horizon. In terms of forecast error variance decompositions 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 securitisation 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 securitisation amplifies the effects of both shocks is again consistent with the presence of a financial accelerator mechanism. If we assume that securitisation 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 securitisation 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 securitisation permits international investors to invest into mortgage debt directly. This could strengthen the effects of capital inflows on the domestic housing market.

4 Conclusion

In this study we examine several potential explanations for housing sector booms: monetary policy, capital inflows and excessive financial innovation. We use a Panel VAR framework and identify monetary policy and capital inflows shocks with sign restrictions. We also split our sample into countries with high and low mortgage market development and allow the coefficients of our VAR to vary with the degree of securitisation. Both methods permit us to asses whether the structure of the mortgage market affects the transmission of macroeconomic shocks to the housing sector.

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 and in countries where securitisation is more prevalent. 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, risk premia and lending are more sensitive to changes in the risk-free rate, since small changes in the interest rate can have a large effect on their ability to serve the debt. As a result, housing demand becomes more sensitive to interest rates. We find that the amplification effect of securitisation is

stronger for capital inflows than for monetary policy shocks. A potential explanation is that mortgage-backed securitisation allows international investors to invest into domestic mortgage debt directly.

The run-up to the present crisis was characterised 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 than monetary policy. This implies that countries with more developed mortgage markets and a high degree of securitisation 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 securitisation markets, for example, the amplification effect may be reduced.

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A Appendix: 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

B Tables

	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

	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

C Figures

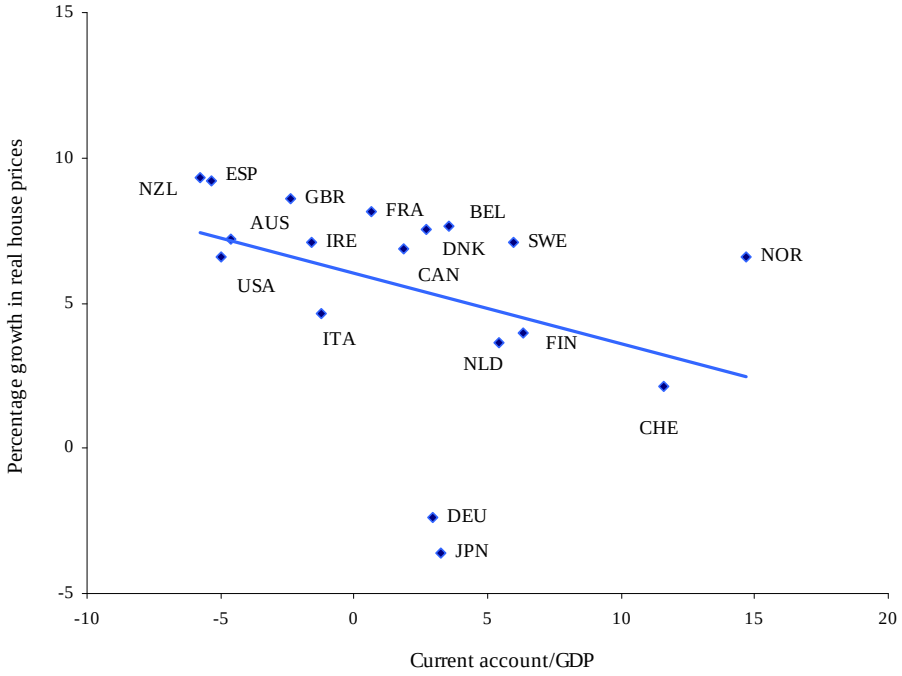

Figure 1: Capital Inflows and House Prices (Quarterly Average 2001q1-2007q4)

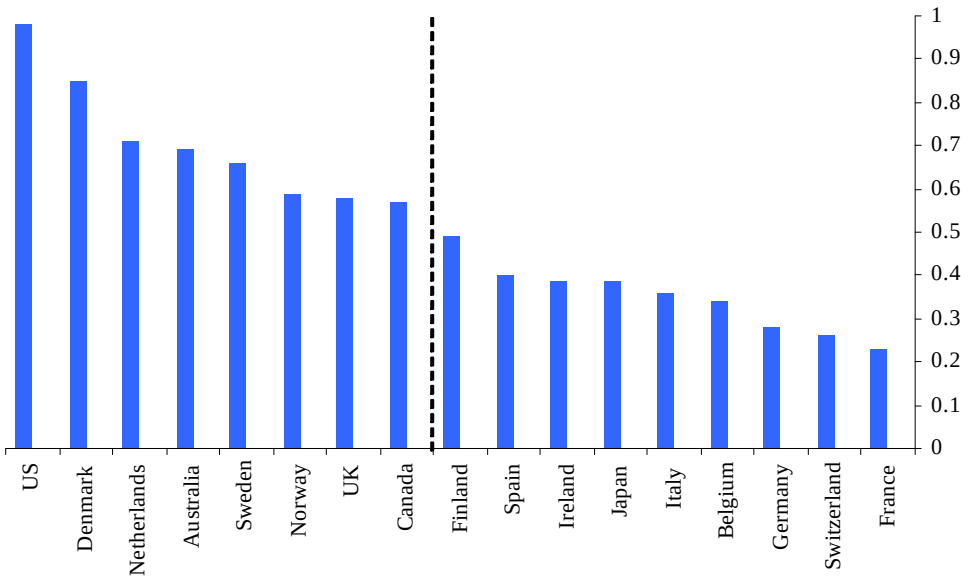

Figure 2: IMF (2008) Index of Mortgage Market Development

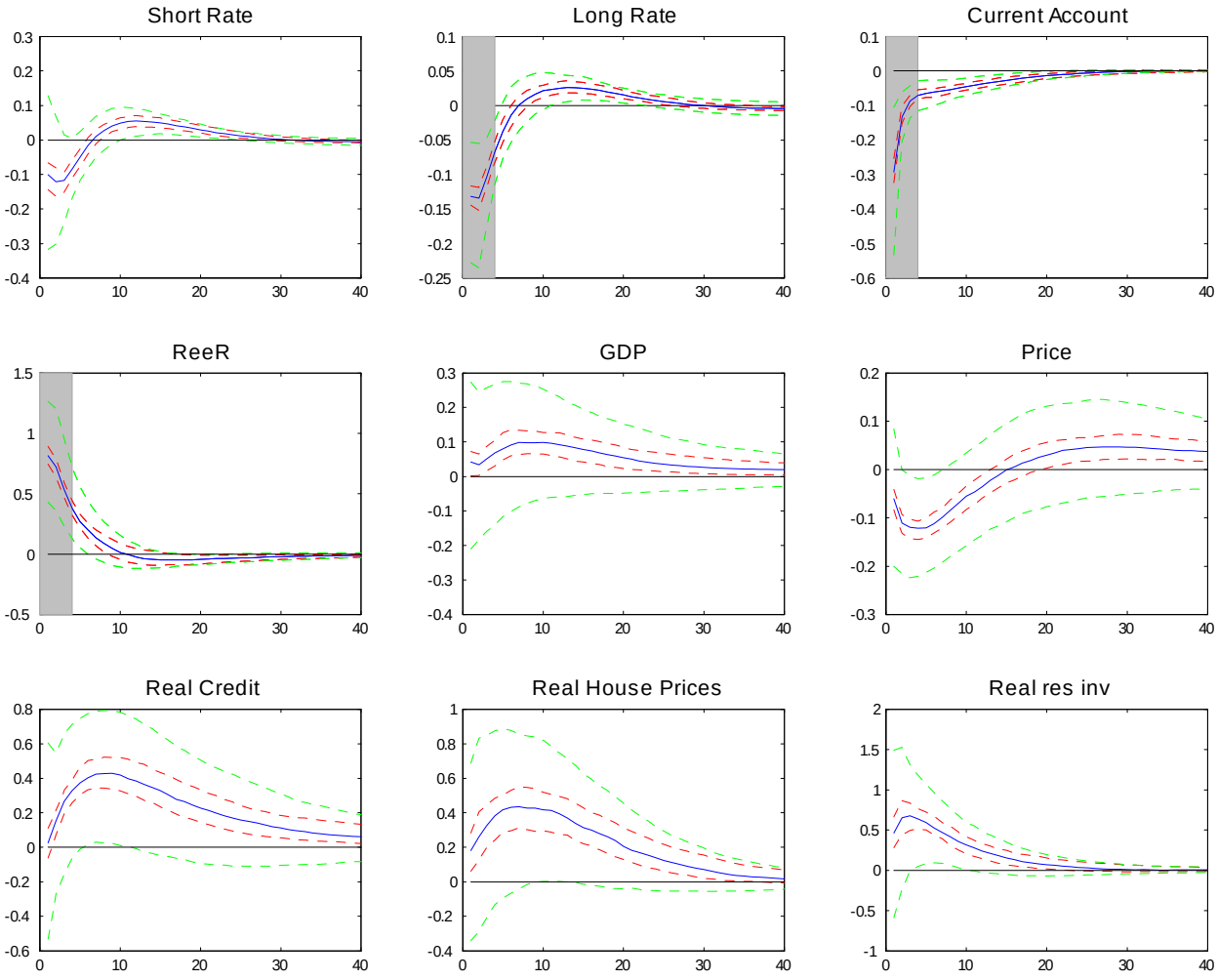

Figure 3: Impulse Responses for Capital Inflows Shock

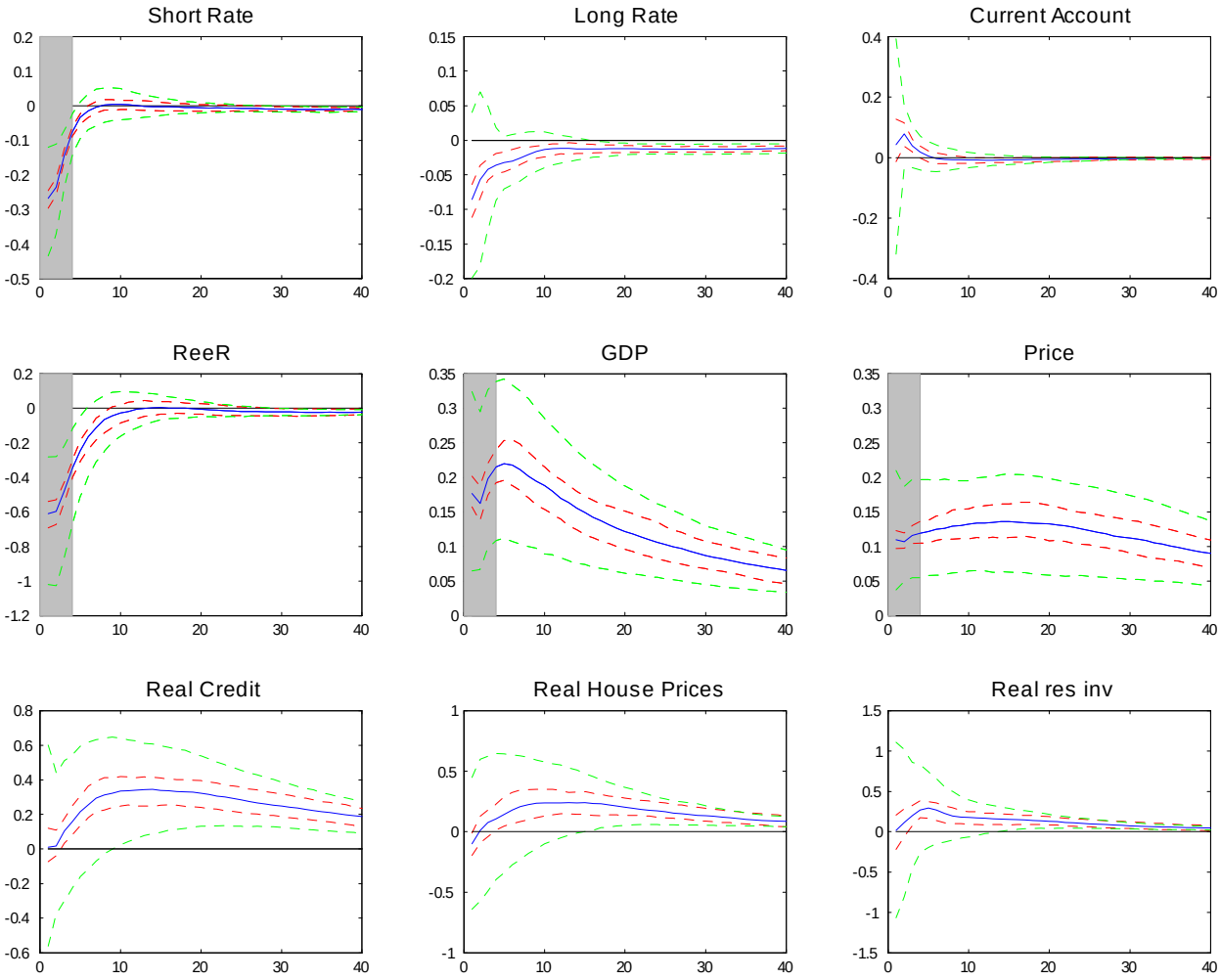

Figure 4: Impulse Responses for Monetary Policy Shock

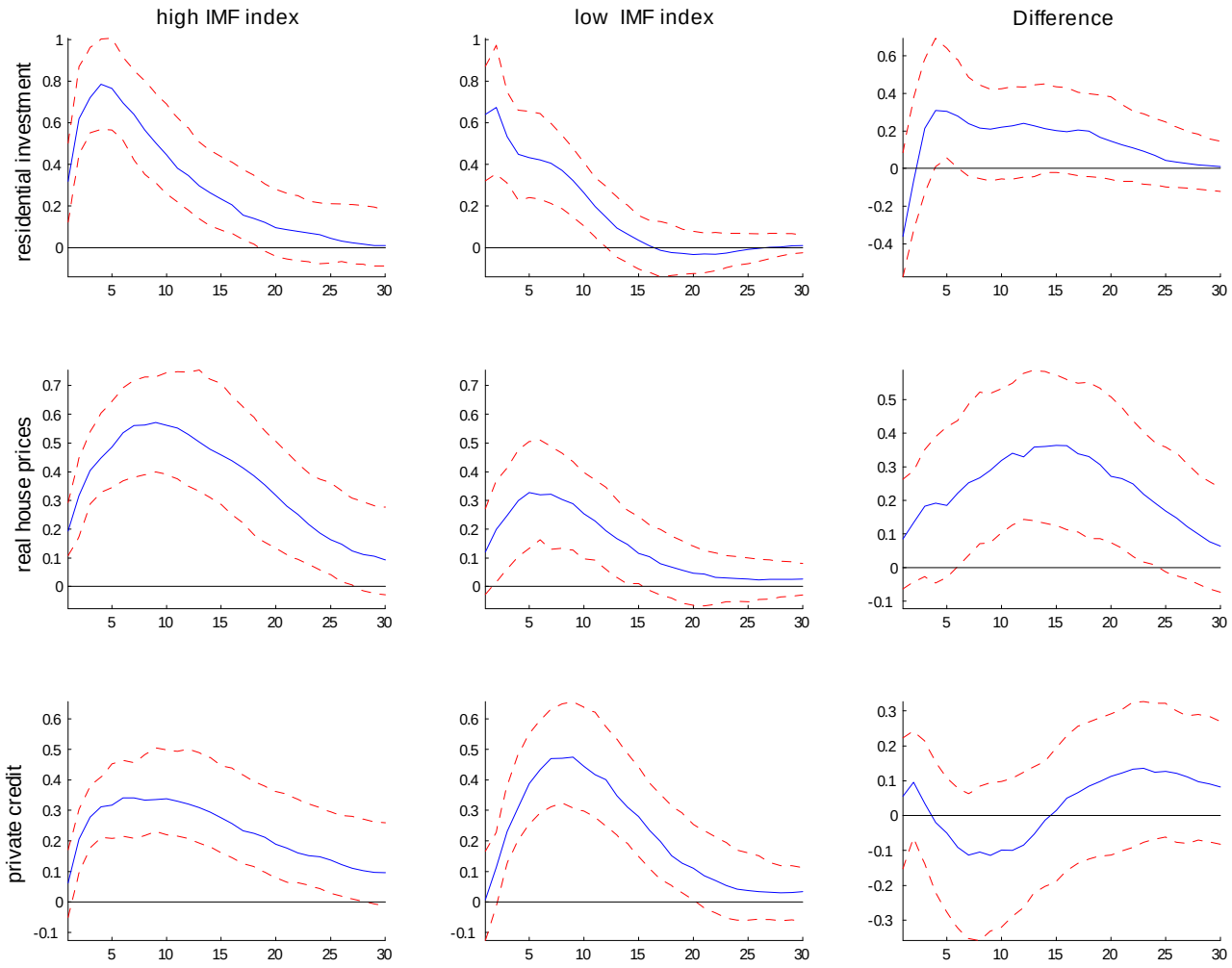

Figure 5: The Role of Mortgage Market Development: Capital Inflows Shock

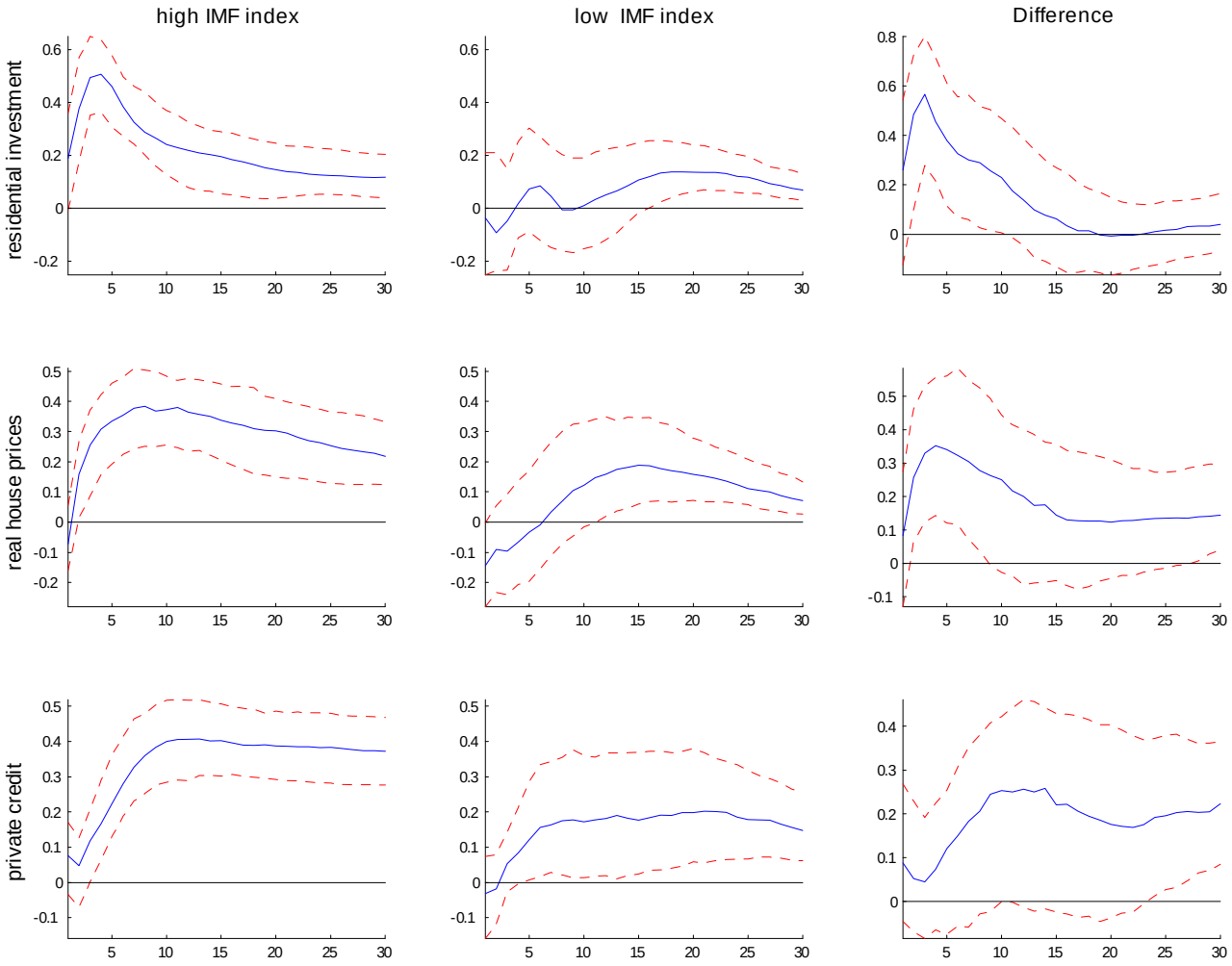

Figure 6: The Role of Securitisation: Monetary Policy Shock

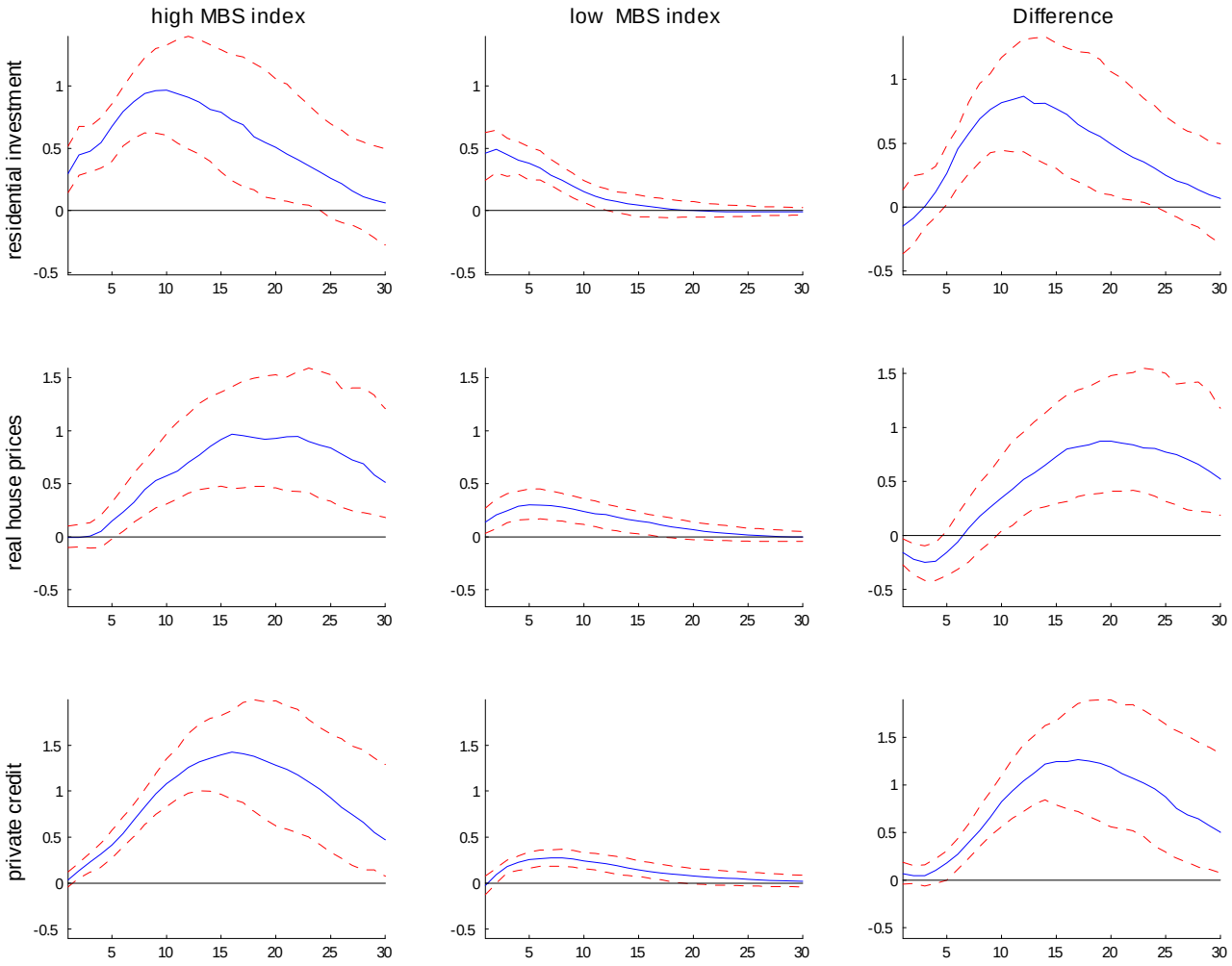

Figure 7: The Role of Securitisation: Capital Inflows Shock

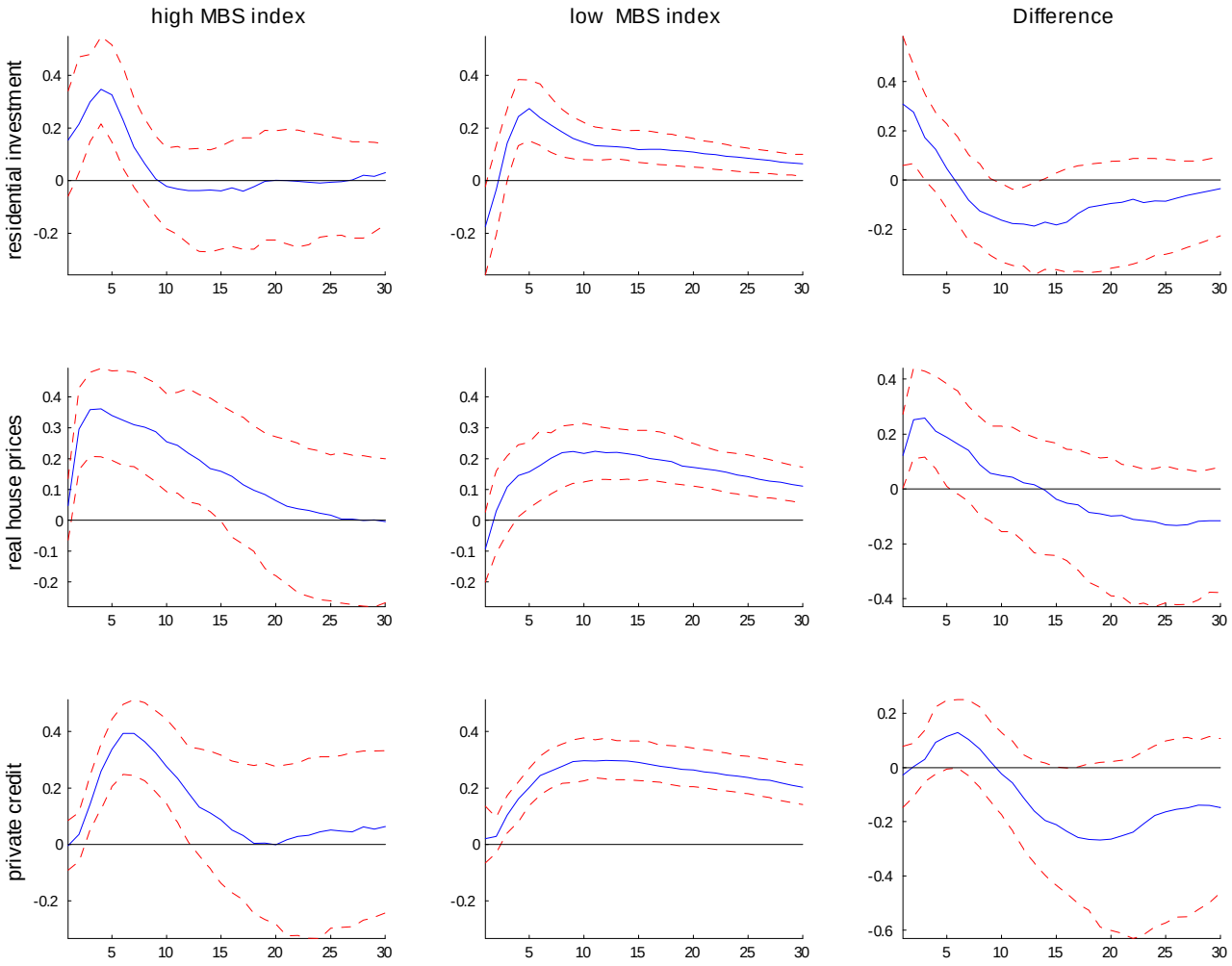

Figure 8: The Role of Securitisation: Monetary Policy Shock