Financial Structure and the Impact of Monetary Policy on Asset Prices

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Abstract

We study the responses of residential property and equity prices, inflation and economic activity to monetary policy shocks in 17 countries in the period 1986-2007, using single-country VARs and panel VARs in which we distinguish between groups of countries depending on their financial systems. The effect of monetary policy on property prices is only about three times as large as its impact on GDP. Using monetary policy to guard against financial instability by mitigating asset-price movements thus has sizable effects on economic activity. While the financial structure influences the impact of policy on asset prices, its importance appears limited.

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1. Introduction

There is much agreement that asset prices, in particular residential property prices, provide a crucial link through which adverse macroeconomic developments can cause financial instability.[1] Episodes of asset price booms are seen by many as raising the risk of a future sharp "correction" of prices, which could have immediate repercussions on the stability of financial institutions. Indeed, many observers have argued that property-price collapses have historically played an important role in episodes of financial instability at the level of individual financial institutions and the macro economy (e.g. Ahearne et al. 2005, Goodhart and Hofmann 2007).

Not surprisingly, this view has led to calls for central banks to react to movements in asset prices "over and beyond" what such changes imply for the path of aggregate demand and inflation (Borio and Lowe 2002, Cecchetti et al. 2000). Proponents of such a policy emphasise that episodes of financial instability risk depressing inflation and economic activity below their desired levels. Consequently, they argue, central banks that seek to stabilise the economy over a sufficiently long time horizon may need to react to current asset-price movements (Bean 2004, Ahearne et al. 2005). Importantly, this idea does not mean that asset prices should be targeted, only that central banks should be willing to tighten policy at the margin in order to slow down increases in asset prices that are viewed as being excessively rapid in order to reduce the likelihood of a future crash that could trigger financial instability and adverse macroeconomic outcomes.

While seemingly attractive, this proposed policy presumes that central banks are able to identify in real time whether asset prices are moving too fast or are out of line with fundamentals. Of course, it is by no means clear that they are better able to judge the appropriate level of asset prices and the risk of future sharp price declines than agents transacting in these markets. Furthermore, the policy has implications for the speed by, and the extent to which, monetary policy impacts on the economy (Bean 2004, Bernanke 2002, Kohn 2006). First, changes in policy-controlled interest rates must have stable and predictable effects on asset prices. Second, the effects of monetary policy on different asset

[1] The chapters in Hunter et al. (2003) provide an overview of the interlinkages between monetary policy, asset prices and financial stability.

prices, such as residential-property and equity prices, must be about as rapid, since stabilising one may otherwise lead to greater volatility of the other. Needless to say, if these criteria are not satisfied simultaneously, any attempts by central banks to offset asset-price movements may simply raise macroeconomic volatility, potentially increasing the risk of financial instability developing. Third, the size of interest-rate movements required to mitigate asset-price swings must not be so large as to cause economic activity and, in particular, inflation to deviate substantially from their desired levels since, if this were to be the case, the resulting macroeconomic cycles could lead the public to question the central bank's commitment to price stability. Fourth, the effects of monetary policy on asset prices must be felt sufficiently rapidly so that a tightening of policy impacts on asset prices before any bubble would burst on its own (since policy should otherwise presumably be relaxed to offset the macro economic effects of the collapse of the bubble).[2]

Unfortunately, however, it is unclear whether monetary policy has predictable effects on asset prices and, if so, whether these effects occur at about the same time horizons for different asset prices, whether they are large relative to the effects of monetary policy on inflation and economic activity, and whether they materialise faster than the effects on inflation and economic activity. While the "over and beyond" approach to monetary policy and asset prices is seemingly attractive, further work on the transmission mechanism of monetary policy and the role of asset prices is thus warranted.

This paper is part of that work and seeks to shed light on the impact of monetary policy on residential-property and equity prices, inflation and output growth. To do so, we establish empirical regularities, as captured by the impulse-response functions of vector-autoregressive models (VARs), that theoretical models of the relationship between monetary policy and asset prices must account for. Instead of testing any specific hypothesis, we follow the research strategy of Goodhart and Hofmann (2008), which estimates VARs that uses minimal identifying assumption to study closely related issues. One attractive feature of both papers is that they look at a broad cross section of countries, which experienced asset price

[2] Bean (2004) and Kohn (2006) discuss the implications of transmission lags for the use of monetary policy in the face of asset-price bubbles.

movements of varying severity and at varying points in time.[3] This avoids the bias that comes from looking mainly at countries that have undergone particularly pronounced asset-price cycles.

We also investigate the role of financial structure for the link between monetary policy and asset prices. A number of authors have argued that the strength of the transmission mechanism depends on institutional characteristics of the financial system.[4] In particular, it has been argued that the reaction of output and inflation to monetary policy shocks is likely to be stronger in financial systems that are more "flexible" and market based. The existing literature has proposed a number of statistical measures – such as relative importance of fixed versus floating rate lending, or average loan to valuation ratios – to capture these characteristics. In studying the importance of the financial structure, we simply use various statistics reported in the literature.

To perform the analysis we study a panel of 17 OECD countries using quarterly data for the period 1986-2007.[5] The analysis proceeds in three steps. Following Iacoviello (2002) and Giuliodori (2005), we first study the impact of monetary policy on the economy by fitting VARs for individual countries.[6] Not surprisingly, the resulting estimates are imprecise, leaving considerable uncertainty about the quantitative effect of changes in interest rates on asset prices relative to their impact on economic activity and inflation, as would seem to be an important precondition for monetary policy to be used to mitigate asset-price movements. Moreover, it is difficult to know whether these differences are significant and whether they depend on the financial structure.

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[3] See also Goodhart and Hofmann (2007).

[4] The importance of financial structure is emphasized by so many authors that it is impossible to provide a full overview here. See, among others, Maclennan et al. (1998), Giuliodori (2005), Tsatsaronis and Zhu (2004), CGFS (2006) and Calza et al. (2007).

[5] Goodhart and Hofmann (2008) also study 17 countries but use a somewhat longer sample, which starts in 1973, and also investigate the importance of money and credit for asset prices. Moreover, they seek to distinguish between boom and non-boom periods. However, they estimate their panel VAR using the standard fixed-effect panel estimator, which is likely to yield biased results for reasons we discuss below.

[6] Sutton (2002) and Tsatsaronis and Zhu (2004) also estimate VARs incorporating residential property prices for a range of countries. The focus of their studies, however, is on which factors explain movements in residential property prices and not on whether monetary policy can be used to stabilize asset price movements.

To raise the precision of the estimates, we thus follow Goodhart and Hofmann (2008) and estimate a panel VAR (PVAR) incorporating real residential-property and real equity prices. Our results show that while monetary policy does have important effects on asset prices, those effects are not particularly large relative to those it has on inflation and output. This suggests that attempts to stabilise asset prices by using interest rate policy are likely to induce pronounced macroeconomic fluctuations.

However, while the panel estimates confirm that monetary policy has predictable effects on residential-property prices, by construction these estimates disregard all country-specific information. In order to study the importance of institutional factors, we go on to split the sample of countries into two groups depending on their financial structure. We then estimate a panel VAR for each group and explore whether the impact of monetary policy on asset prices, inflation and output differs between the two groups. We use several measures proposed in the literature to capture differences in financial structure, including the importance of floating rate lending; whether mortgage equity withdrawal is possible; the loan-to-value ratio for new mortgages; the mortgage-debt-to-GDP ratio in the economy; the method used to value property; whether mortgages are securitised; and the share of owner occupied dwellings. Since the notion of a financial system is a multi-faceted concept and these measures each only capture one aspect, it is possible that they lead to an underestimate of the importance of institutional factors. We therefore end the study by using the mortgage market index recently proposed by the IMF (2008) to capture the joint impact of financial market characteristics on the monetary transmission mechanism. To preview briefly the results, we find that the financial structure does condition the responses of asset prices to monetary policy but also that the differences between country groups are less important than perhaps commonly thought.[7]

The paper is organised as follows. The next section contains a discussion of the data and Section 3 presents the results for the VARs estimated for individual countries. In Section 4 we first briefly discuss panel VARs before discussing the estimates. Section 5 focuses on the importance of financial structure and provides panel-VAR estimates when the countries are divided into two groups on the basis of financial structure. Finally, Section 6 concludes.

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[7] See Maclennan et al. (1998) for a dissenting opinion.

2. Data

The econometric analysis below is conducted on quarterly data on equity and residential property prices, consumer price indices (CPIs), real gross domestic product (GDP) and interest rates.[8] Much of the interest in the behaviour and determination of asset prices stems from their role in episodes of financial instability. Since there is a natural tendency to focus on data from countries that have experienced pronounced asset-price swings, there is a risk of sample selection bias, which can be mitigated by using data from a broad cross-section of countries. We therefore study 17 countries for which we could obtain both equity and residential property price data: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK and the US.

The sample starts in 1986 in order to avoid the more turbulent, higher inflation period that ended in the first half of the 1980. Moreover, and as noted by Ahearne et al. (2005) and Girouard and Blöndal (2001), many countries deregulated their mortgage markets during the early to mid-1980s, suggesting that estimates relying on older data are unlikely to be representative for modern economies. The data set ends in 2007, which covers the first two quarters of the global financial crisis triggered by the developments in the US subprime mortgage market.[9]

Residential property prices are from the data base of the Bank for International Settlements (BIS). Quarterly data over the whole sample period are available for Australia, Canada, Switzerland, Denmark, Finland, France, the Netherlands, Sweden, the UK and the US.[10] For Belgium we link an older series for small and medium-sized houses to the residential property price series for all dwellings from 1988 on. For Spain we link the residential property prices of existing dwellings with those of owner-occupied homes in 2005. For Ireland and Norway we interpolate annual data with the Chow-Lin (1971) procedure, using

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[8] All results are obtained with the software RATS 7.0.

[9] Goodhart and Hofmann (2008) in their panel VAR analysis also study, as a part of their robustness analysis, a sub-sample spanning 1986 to 2006 and find that this later period indeed differs from the earlier part of their sample. However, their data series are somewhat different from those we use here.

[10] For Australia, missing values for the first two quarters of 1986 were generated using the growth of residential construction cost.

a rent index and an index of residential construction cost as reference series, and link the resulting series to the BIS quarterly data that start in 1988 and 1991, respectively.[11] The same interpolation procedure is applied to annual property price data for Germany and Italy.[12] For Japan the semi-annual series on residential land prices is interpolated.[13]

Figure 1 shows the resulting residential property price series.[14] Interestingly, many economies experienced a sharp rise in residential property prices in the second half of the 1980s, in many cases associated with liberalisation and deregulation of the housing finance sector. Residential property prices were subsequently weak or fell in the 1990s, following the US recession in 1990-1991 and the episode of high interest rates in many European countries after the turmoil in the European exchange rate mechanism (ERM) in 1992-93, which was triggered by the adoption of tight monetary policy in Germany to offset the aggregate demand effects of German Reunification. In the early 2000s, several countries – in particular Belgium, Denmark, Spain, the UK and the US – again experienced large increases in residential property prices. The figure also indicates that Japan and Germany do not follow this general pattern. After the collapse of the "bubble economy" in Japan around 1990, residential property prices fell continuously until the end of the sample. In Germany, residential property prices started falling in 1994 and declined until 2006, vividly indicating the depth of the "German crisis."

Before proceeding, it should be emphasised that data on residential property prices are not necessarily comparable across countries. The main differences concern the type of housing that is included (single family houses, flats or all types), whether existing dwellings or new dwellings are considered, whether prices are per dwelling or per square meter, and the region (urban, non-urban or both) where the data is collected. While price developments vary between types of housing reflecting supply and demand conditions in different market segments, the most noticeable differences arise with respect to the area where the data come

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[11] Annual data for Norway are from Eitrheim and Erlandsen (2004).

[12] Annual property price data for Italy are taken from Cannari et al. (2006).

[13] In Japan, a market for old homes practically does not exist as houses are normally torn down after a few decades. As a consequence, land prices determine the value of housing, see the Economist (2008).

[14] We note that despite the difference in data sources, the patterns are comparable to those reported in Tsatsaronis and Zhu (2004) and Ahearne et al. (2005).

from. Property-price booms generally occur in metropolitan areas, and are often less pronounced if data for the whole country are considered. The impact of this, however, is difficult to assess since only few countries have series covering these different categories. As an example, Figure 2 shows the annual increase in nominal UK residential property prices for the whole country and the greater London area. While the prices in the latter area seem more volatile, the two series evolve in much the same way over time (their correlation is 0.82). The right-hand panel shows the annual increase in prices for single-family houses and flats in Switzerland. Again, the year-to-year changes differ somewhat but generally convey the same information (the correlation is 0.86). For our study we use whenever possible the broadest residential property price index available in order not to capture regional booms. Nevertheless, great care needs to be exercised when comparing property-price developments across countries.

Turning to the sources of the other data, the CPI (all items) and share price indices (all shares) are from the OECD Main Economic Indicators (MEI) data base. Real GDP data were taken from the BIS data base and supplemented with data from the International Financial Statistics (IFS) data base of the IMF. For Ireland annual GDP data before 1997 were interpolated with the Chow-Lin (1971) procedure using industrial production as the reference series. We use a three-month interbank rate for Denmark, Switzerland, Spain, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway and the UK, a three-month Treasury bill rate for Belgium, Sweden and the US, and a three-month commercial paper rate for Australia, Canada and Japan.[15] All interest rates are from the OECD's MEI. For Finland and Denmark missing data for 1986 were replaced with data from the IFS (call money rate). For the euro-area countries we use the three-month EURIBOR rate after 1998. Except for interest rates and equity prices all data are seasonally adjusted.

3. VARs for individual economies

We start by estimating VAR models for individual countries, following the approach taken by Giuliodori (2005), Iacoviello (2002) and Neri (2004). We include five variables: the CPI (p),

[15] To eliminate a large spike during the ERM crisis we regressed the three-month interest rate for Ireland on a dummy, which is unity in 1992Q4 and zero elsewhere, and used the fitted value in the analysis.

real GDP (*y*), the three-month interest rate (*i*), residential property prices (*pp*) and equity prices (*eq*). Except for the interest rate, all variables are in logarithms. Before we turn to the econometric analysis it is useful to investigate the time-series characteristics of the data.

Table 1 reports results for the individual countries. Interest rates and equity prices are all nonstationary in levels but stationary in first differences. For GDP stationarity in levels is rejected only for Japan while nonstationarity of the first differences is rejected only for Finland and the UK. The results for the CPI and residential property prices are less clear cut. While the levels generally appear nonstationary, in more than half of the cases we do not reject nonstationarity of the first differences. Since we take a panel approach below, we therefore also perform panel unit root tests that provide a summary assessment of whether a variable can be regarded as stationary or not. We use the panel unit root test proposed by Im, Pesaran and Shin (2003) that allows for heterogeneity in the dynamics of the time series. Based on the results from the panel unit root tests, we consider all variables as integrated of order one, I(1).[16]

Next we test for cointegration between the variables.[17] When using a common lag length of four (which is sufficient to eliminate any seasonal pattern in the residuals for quarterly data) for all countries, the existence of at least one cointegrating vector was not be rejected. We therefore specify the VAR models in the levels of the variables. Nevertheless, we neither impose the number of cointegrating relations on the systems nor do we attempt to impose overidentifying restrictions on the cointegrating vector.

For an individual country n, $n = 1, \ldots, N$, the reduced form of the VAR can be written as $Y_{n,t} = \mu_n + A_n(L)Y_{n,t} + \varepsilon_{n,t}$, where $Y_{n,t} = (p_{n,t}, y_{n,t}, i_{n,t}, pp_{n,t}, eq_{n,t})$, μ_n is a constant, $A_n(L)$ is a matrix polynomial in the lag operator and $\varepsilon_{n,t}$ is a vector of normally, identically distributed disturbances. For each country the number of lags included in the VAR is chosen by the Akaike information criterion, considering a maximum lag length of four.

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[16] Interestingly, the panel unit root test indicates that the CPI is stationary around a trend. See Gerlach and Knüppel (2009) for a discussion.

[17] Iacoviello (2002) argues that a long-run relation between GDP and real residential property prices should exist.

To study the monetary transmission mechanism, we investigate the responses of the different variables to monetary policy shocks.[18] We use a Choleski decomposition to identify the shocks, with the variables ordered as above, which is standard in the monetary transmission literature (see Christiano et al. 1999). This triangular identification structure allows output and the price level to react only with a lag to monetary policy shocks, whereas property and equity prices may respond immediately. We thus assume that central banks react to current output growth and inflation when setting interest rates, but not to current property and equity prices.[19]

While this last assumption may seem controversial in that few observers would doubt that central banks react to changes in asset prices since these influence aggregate demand and inflation pressures, barring exceptional circumstances one would not expect any reactions to be instantaneous but rather to occur if asset prices rise or fall for some time. By contrast, asset prices react immediately to changes in monetary policy. Thus, it seems sensible to attribute the contemporaneous correlation between interest rates and asset prices to reactions by the latter to the former rather than conversely. We have explored whether the results are sensitive to this assumption. Not surprisingly, for equity prices the ordering does matter but for residential property prices it does not. However, the alternative assumption that the contemporaneous correlation between innovations in interest rates and equity prices is due solely to reactions by monetary policy is not only implausible for the reasons mentioned, but also leads to counterintuitive results. For instance, equity prices start to increase after a contractionary monetary policy shock.[20] It therefore seems appropriate to order the interest rate before the asset prices in the system.

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[18] Of course, monetary policy is best characterised by the central bank's systematic reactions to developments in the variables in the VAR, which are captured by the estimated coefficients. However, we are interested in the question of how asset prices react to a change in the interest rate, keeping the other variables constant. To address this question, we need to identify monetary policy shocks (see Christiano et al. 1999 or Walsh 2003, Chapter 1, for a discussion of these issues).

[19] To identify the monetary policy shock it is sufficient to determine the position in the triangular ordering of the monetary policy instrument; the ordering of the variables in the groups before and after the interest rate does not matter.

[20] A rise in equity prices after a contractionary monetary policy shock is inconsistent with results obtained with structural identification assumptions relying on the long-run effects of monetary policy, see Lastrapes (1998).

Figure 3 shows the mean bootstrapped impulse responses to a monetary policy shock of 25 basis points in the single-country VARs. Since these models involve the estimation of a large number of parameters, impulse responses are imprecisely estimated. Many analysts therefore use plus/minus one standard-error (i.e., 68%) confidence bands. We therefore do so too. However, the impulse responses arising from the panel VARs we estimate below are more precisely estimated since the data are pooled. To take that into account when conducting inference, we use plus/minus two standard-error (i.e., 95%) confidence bands in this case. In order to permit comparison with the single country VARs, we show plus/minus one and plus/minus two standard-error wide bootstrapped confidence bands in all graphs. Given the large number of impulse responses generated by the estimation process, we focus on the general features of the results.

As a preliminary, note that the impulse responses are frequently statistically insignificant even when the 68% confidence bands are used. After a monetary policy shock the CPI falls, though in most countries it takes about 15 to 20 quarters before the maximum effect is felt. Nevertheless, in some countries the CPI rises in the short run, indicating the presence of a "price puzzle."[21] Because of the wide confidence bands, however, this effect is significant only in Australia, Canada, Sweden, Switzerland and the UK. Real GDP declines after a monetary policy shock in all countries, and significantly so in about half of them. It is notable that GDP reacts much faster than the CPI to a monetary policy shock.

Of particular interest is the reaction of asset prices. Except for Germany and Spain, residential property prices fall in reaction to monetary policy shocks. Furthermore, the results appear to differ between countries: the fall of residential property prices is significantly different from zero even at the 95% level in Canada, Finland, the Netherlands, Norway, Sweden, Switzerland, the UK and the US. Moreover, while in some countries, (including Finland, the UK and the US) residential property prices respond immediately to a monetary policy shock, in others, (e.g., Belgium or Spain), the responses are much slower and more persistent. However, the confidence bands are wide and it is hard to tell whether the responses differ systematically across countries. The reaction of equity prices to

[21] The price puzzle arises because central banks change interest rates in response to predicted future changes in inflation, that is, information that the econometrician does not incorporate in the analysis. See Walsh (Chapter 1, 2003) for a discussion.

monetary policy shocks is generally negative and often significant on impact but typically becomes insignificant after a few quarters.

It should be noted, as shown by Figure 3, that the typical path of the interest rate after an initial 25 basis-points increase differs widely across countries. One would expect a stronger reaction of the variables if the interest rate returns to its initial level slowly or even overshoots, as is the case for Australia, than when the reactions of the interest rate are short-lived, as in France or Ireland.[22] Differences in the impulse responses could therefore also be due to the fact that the interest rates themselves evolve in different ways following a monetary policy shock.

Since we are interested in gaining a broad understanding of the effects of monetary policy on the economy, we go on and estimate PVARs that allows us to quantify the average response of real residential-property and equity prices in the 17 countries in our data set to typical monetary policy shocks. One reason this is helpful is that while the results for the single-country VARs are inconclusive and frequently insignificant, we are likely to obtain more precise estimates by exploiting the cross-sectional information in the data.

4. Panel VARs

There is a large literature on the estimation of panel regressions and the inconsistency that can arise in that context. Much of that literature deals with the bias of the fixed-effects estimator in dynamic homogeneous panels that results from the inclusion of lagged endogenous variables (Holtz-Eakin et al. 1988). This bias is particularly severe if the time dimension is small but can be overcome by using GMM or instrumental-variables estimators. Since our sample period is rather long, we are not overly concerned about this source of bias.[23]

Unfortunately, even if the time dimension is large, the standard fixed-effects estimator is inconsistent in dynamic panels if the coefficients on the lagged endogenous variables differ across groups, which is likely in our case as a consequence of divergent financial structures.

[22] Standard New-Keynesian models imply that the persistence in the reaction of output and inflation is higher when monetary policy reacts more strongly to deviations of output from baseline. We are grateful to an anonymous referee for drawing our attention to this point.

[23] Nickel (1987) shows that this bias is an order of magnitude smaller in panel models than single-equation time-series models.

The reason for this inconsistency is that restricting the slope coefficients to be the same across groups induces serial correlation in the residuals when the regressors are autocorrelated. This serial correlation does not vanish when instrumental variable estimation is applied (see Pesaran and Smith 1995). Figure 4 shows the impulse responses to a 25 basis points shock to the interest rate in the PVAR when using the conventional fixed effects estimator. It is apparent that all responses show implausibly strong persistence, e.g., the peak response of GDP is attained only after 14 quarters. This is much later than in the country VARs where the peaks generally occur after about five quarters. Moreover, we obtain a significant and persistent price puzzle. In light of this problem, we follow Pesaran and Smith's recommendation and estimate the PVAR by the mean-group estimator. This estimator assumes that the parameters vary cross-sectionally and provides a consistent estimate of the mean effects by averaging the coefficients across countries.[24]

More formally, the panel VAR can be written as $Y_{n,t} = \mu_n + A(L)Y_{n,t-1} + \varepsilon_{n,t}$, where $Y_{n,t}$ is a $N \times 1$ vector containing the observations for the N countries, $n = 1, \ldots N$; μ_n is a country-specific intercept and $A(L)$ is a lag polynomial with the VAR coefficients. The disturbances, $\varepsilon_{n,t}$, have zero means and a country-specific variance, σ_n^2. We assume that the coefficients in $A(L)$ vary randomly across countries and that the typical element $a_{i,j}^p$ in $A(L)$ can be written as $a_{i,j}^p = a_{n,i,j}^p + \eta_{n,i,j}^p$, where n is the country index, $p = 1, \ldots, P$, the lag order of the VAR and i, $j = 1, \ldots K$ the number of variables in the VAR. Our interest is in the mean parameter value, $a_{i,j}^p$.

Figure 5 shows the impulse responses to monetary policy shocks implied by the panel regression using the mean-group estimator. Not surprisingly, the large increase in information that comes from using the panel approach generates impulse responses that typically are significantly different from zero at the 95% level.

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[24] The fixed-effect estimator assumes that coefficients across countries are the same. If this assumption is true, using the mean-group estimator is inefficient. If it is wrong, the fixed-effects estimator is biased. Since we estimate reduced-form coefficients, there is no theoretical reason to believe that the coefficients across countries should be the same. Goodhart and Hofmann (2008) employ the fixed-effect estimator.

Again, we consider the responses to a 25 basis point increase in the interest rate. After a monetary policy shock it takes six quarters before the price level starts to fall, with the effect becoming significant only after about two years. This slow response may be a consequence of some countries showing a "price puzzle" in their reaction to a monetary policy shock.[25] Furthermore, the results indicate that output falls for about six quarters in response to the monetary policy shock before recovering slowly. Residential property prices reach their trough somewhat earlier after three quarters but take even longer to recover. By contrast, equity prices, which are forward-looking variables, fall immediately following the increase in interest rates and have returned to the original level by the time output and property prices have returned about half way to their initial levels.

These findings warrant several comments. First, the reactions of prices and output to the shocks are similar to those found in the literature based on single-country studies (see, e.g. Christiano et al. (1999) for the US and the VAR studies in Angeloni et al. (2003) for the euro area). Second, the responses of residential property prices lead those of real GDP by about three quarters. This suggests that changes in property prices influence GDP via their effects on wealth and consumption demand. Third, the width of the confidence bands indicates that the responses of residential property prices are, statistically, about as well defined as the impact on real economic activity. Fourth and most importantly, the point estimate shows that after about one year residential property prices have fallen about three times as much as the level of real GDP, that is, by 0.375% rather than by 0.125%.

Of course, these estimates, in particular the three-to-one estimate, reflect the policy choices made by central banks in the sample period during which central banks did not seek to stabilize asset prices. Thus, it is possible, as suggested by the Lucas critique, that the estimates would change if central banks started to do so. As they stand, the results suggest that while monetary policy could in principle be used to offset swings in residential property prices that are seen as causing a threat to financial stability, it risks inducing potentially large swings in real economic activity. For instance, to offset a 15% rise in residential property prices, which is not an unusually large increase by the standards of many recent property

[25] While our results do not indicate the presence of a price puzzle, we nevertheless believe that the estimates underpredict the impact of monetary policy on the level of prices since we do not include indicators or predictors of future inflation in our VAR system.

price booms, the central bank must be willing to depress real GDP by 5%, a substantial amount.[26] Moreover, while the impact of monetary policy shocks on equity prices is about as large as the peak effect on residential property prices, the marked difference in timing implies that monetary policy cannot easily be used to target both.

Overall, the results in this section suggest that gearing monetary policy to asset prices is likely to generate pronounced swings in economic activity and to stabilise some asset prices at the costs of inducing more instability in others.

5. How important is financial structure?

One problem with the panel VAR estimates is that they mask any potential heterogeneity across the 17 countries in our sample. This is unfortunate since many authors have argued that the impact of monetary policy on the economy varies across countries depending on the financial structure of the economy (Cecchetti 1999, Ehrmann et al. 2003, Giuliodori 2005). Moreover, it is well documented that the financial structure differs significantly between the countries we consider (Maclennan et al. 1998; Calza et al. 2007). However, little quantitative evidence on the importance of these characteristics has been presented in the literature.[27] One problem with doing so is the nature of the available data. Institutional characteristics change little over time, so that time series analysis with such data is precluded. Moreover, while there are several characteristics that might influence the effects of monetary policy on financial stability, there is no agreement on which characteristics are most important and how best to measure these. With these caveats in mind, we selected a number of potentially relevant criteria from the literature, divided the countries in two groups on the basis of these criteria and estimated a panel VAR for each group in order to assess the importance of

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[26] See also Assenmacher-Wesche and Gerlach (2008a, b). Proponents of using monetary policy to mitigate swings in asset prices, such as Borio and Lowe (2002), do not seem concerned by the impact of such a policy on economic activity. By contrast, opponents, such as Kohn (2006), emphasise the effects on output and inflation. Interestingly, experimental evidence also shows that interest rate policy is not effective in dealing with asset price bubbles, see Becker et al. (2007).

[27] An exception is Calza et al. (2007) who compute correlations between the peak effect of a monetary policy shock and mortgage market indicators. Of course, there is no lack of cross-country studies that find differences in monetary transmission and attribute these to differences in financial structure. However, the estimated impulse responses may differ for many other reasons, including the conduct of monetary policy and other differences in economic structure that are not taken into account. Here we investigate the effect of financial structure more directly.

financial structure.[28] In that way we are able to focus on the differences that are related to this specific feature of financial markets, while other country-specific idiosyncrasies should average out.

We emphasise that information on financial structure from different sources are not always comparable. One example is the loan-to-valuation (LTV) ratio, where some studies quote the maximum, while others refer to the average LTV ratio. In addition, judgement is required when grouping countries according to these criteria. Consider, for instance, the classification of countries as having fixed or flexible mortgage interest rates. While a majority of mortgages with an interest-rate adjustment at three months' notice certainly classifies as flexible, it is much more difficult to decide whether interest rates that are fixed between one and five years (e.g., Italy; see Calza et al. 2007) should be regarded as fixed or flexible. Any grouping of countries is therefore subjective and consequently disputable.

The problems measuring the state of the financial structure influence our research design in several ways. First, we analyse a broad range of indicators, which are summarised in Table 2, to ensure that we capture as many as possible aspects of the structure of mortgage financing.[29] To avoid influencing the results, we do not compile these indicators ourselves but rely on some that have been published in the literature.

Second, we use a robust approach to study the importance of financial structure by comparing the transmission mechanism in two groups of countries consisting of those with the five highest, and those with the five lowest, values of the respective quantitative characteristics. When interpreting the results, it is important to verify that the use of different criteria is not leading to the same allocation of countries to the two groups. By leaving out some countries in these groupings, the correlation across the groupings is greatly reduced.

Grouping the countries also reduces the problems arising from the fact that the indicators pertain to a specific point in time and thus disregard the fact that the financial structure evolves. However, Goodhart and Hofmann (2008) argue that the *relative* position of countries

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[28] To keep results between the different groupings comparable we estimate all VARs with four lags.

[29] We concentrate on indicators of mortgage finance because these are the indicators available in the literature. Monetary policy will also influence financing conditions for firms differently depending on financial structure. Since such indicators are not readily available for the countries studied here, we do not consider this aspect.

changes little over time. If so, our approach of distinguishing between countries with the five highest and five lowest values of the different criteria may be robust to changes in financial structure that occurred in our sample.

Third, we distinguish between countries on the basis of the Mortgage Market Index published by the IMF (2008). The reason for doing so is that while the different individual criteria we use capture one important dimension of financial structure, the strength of the transmission mechanism depends on their overall effect. Thus, it seems useful to consider also some aggregate measure of the financial structure.

With this as a preliminary, we turn to a discussion of the eight characteristics in Table 2, their presumed importance for the monetary transmission mechanism and to the empirical results in Figure 6 to 13.

The first criterion we consider is the importance of floating rate financing. It is commonly believed that in economies, in which mortgage rates are tied to short-term interest rates, changes in monetary policy have relatively large effects on residential property prices and therefore on the economy, since the interest rates on all loans are reset at the same time. By contrast, in the case of fixed-rate lending, only new borrowers are affected by changes in interest rates.[30] It is therefore sometimes argued that fixed-rate mortgages are less risky than floating-rate mortgages. However, an unexpected fall in the steady-state inflation rate exposes fixed-rate borrowers to an increase in the real interest rate. This effect may have been a factor contributing to the fall in residential property prices and the generally weak economic performance in the 1990s in Germany and Japan, both of which rely predominantly on fixed-rate financing.

Next we present the results obtained when we distinguish between countries depending on the prevalence of fixed- versus variable-rate mortgages. Since the reactions of equity prices and the CPI do not differ systematically across country groupings, we plot only the impulse responses for real GDP and property prices to interest rate shocks. The last panel in Figure 6 shows the difference in impulse responses, together with ± one–standard-error-wide confidence bounds. As one would expect, the effects of monetary policy on GDP are larger

[30] See Maclennan et al. (1998). Calza et al. (2007) present a model which implies that the sensitivity of consumption to monetary policy shocks is higher with variable-rate mortgages.

and more persistent when variable-rate mortgages are prevalent, since changes in interest rates then influence the interest rates of the stock of outstanding mortgages. At a horizon of four to nine quarters the difference in responses is significant. Surprisingly, property prices react more quickly in economies with fixed-rate mortgages, which runs counter to the idea that they are a particularly important part of the monetary transmission mechanism in economies in which floating-rate lending is dominant. However, it is difficult to know exactly how important fixed- versus floating-rate mortgages are.[31] Furthermore, the relative importance of fixed rate lending can change over time, depending on the shape of the yield curve (see European Mortgage Federation 2006).

The second feature we consider is the importance of housing equity withdrawal. If households are able to withdraw equity, one would expect them to do so in response to rising residential property prices. This would boost consumption spending and aggregate demand, and might further increase residential property prices. Figure 7 shows that the ability to withdraw mortgage equity does indeed entail a significantly stronger reaction of real GDP for about six quarters after the shock. However, there is no significant difference between groups in the reaction of property prices during this horizon.

A third important characteristic of the financial system is the LTV ratio. A high LTV ratio means that households can relatively easily obtain financing to purchase property, suggesting that the effects of changes in interest rates are likely to be marked. Furthermore, interest rate increases may be more contractionary since households have less equity and thus may be more prone to default in conditions of economic hardship. Figure 8 shows that as expected the reaction of GDP in the high-LTV group is larger though because of the imprecisely estimated response in the low-LTV group the differences becomes significant only after ten quarters. Unexpectedly, property prices react on impact more in the low-LTV group.

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[31] One reason for this is that the maturity of fixed-rate mortgages may be short, say three or five years, that some fixed-rate mortgages allow for early repayment or that borrowers face interest rate risk when the mortgage is rolled over. Moreover, floating-rate mortgages may have the interest rate reset only infrequently or may be tied to long-term interest rates that do not vary much over time.

The fourth characteristic is the mortgage-debt-to-GDP ratio. Since data on the average LTV ratio are difficult to obtain and banks presumably apply different criteria to different borrowers, the ratio of mortgage debt to GDP provides an alternative measure of the responsiveness of the housing market to interest rate changes. Figure 9 shows that the results are similar to those for the LTV ratio. Now the difference in real GDP is significant after the monetary policy shock during the first four quarters. Contrary to our expectation, however, the response of residential property prices is larger in the group with the lower mortgage-debt-to GDP ratio.

The fifth characteristic we study is the valuation method that is used in different countries. If banks are required to value their assets at market prices, monetary policy will have a stronger impact on bank's balance sheets and therefore on property prices and GDP (Adrian and Shin 2008). Furthermore, if lending decisions are based on the current, as opposed to the historical, valuation level, households' ability to borrow will be more sensitive to current economic conditions and monetary policy. Tsatsaronis and Zhu (2004) therefore hypothesise that residential property prices fall faster in economies in which properties are valued using their current market prices. According to Figure 10, however, this hypothesis is not supported by our data. The response of both real GDP and property prices is stronger in economies with mortgage lending valuation. Surprisingly, the reaction of real GDP more persistent when market valuation is used.

The sixth characteristic we assess is whether it matters if mortgage loans are securitised. Tsatsaronis and Zhu (2004) conjecture that the prevalence of securitisation should reduce the sensitivity of residential property prices to monetary policy shocks since it allows banks to transfer the credit risk associated with mortgages to the capital market. Without securitisation the risk of credit crunches would therefore be commensurately larger, implying that the effects of monetary policy may be more pronounced in economies in which mortgage loans are not securitised. On the other hand, it has been argued that the increased reliance on capital markets for mortgage funding associated with securitisation implies stronger effects of monetary policy on the economy and on residential property prices (CGFS 2006). In particular, the subprime crisis has shown that the risk transfer associated with securitisation does not seem to function well at the economy-wide level and that individual banks may underestimate the extent to which shocks are correlated.

Figure 11 suggests that GDP falls by more in economies where securitisation is common. By contrast, securitisation does not seem to have an impact on the reaction of residential property prices to monetary policy shocks.[32]

Finally, we consider whether the share of owner-occupied housing matters. With high owner-occupancy rates, the wealth effect of monetary policy should be important and one would expect a larger impact of monetary policy shocks on GDP (see Maclennan et al. 1998). On the other hand, landlords or institutional investors owning rental housing also will experience a wealth effect and the argument rests on their wealth effect being smaller than that for the owner occupiers. Figure 12 shows that indeed the effects on real GDP and property prices are significantly larger if the share of owner-occupied housing is large, confirming the view that the wealth effect for owner occupiers matters.

Summing up, we generally find a larger reaction of GDP to monetary policy shocks in those countries that have more market-based financial systems. The differences in the reactions of property prices, however, are generally insignificant. This casts doubts on the notion that the effects on monetary policy on real GDP depend critically on the structure of the financial system and the responses of property prices. One potential explanation for this surprising finding is that we have disregarded other important characteristics of the economy that influence the responses to monetary policy shocks – such as the nature of the wage-setting process – or that the indicators used to group countries are poor.[33] It may also be that the characteristics of the mortgage finance system interact with each other, and that their effect can only be detected when they are considered jointly. To explore whether the countries where the criteria generally suggest a large impact of monetary policy on residential property prices and economic activity indeed show a larger reaction to monetary policy shocks we use the mortgage market index calculated by the IMF (2008). The index is supposed to capture the degree of mortgage market development and flexibility and is constructed in such a way that we would expect countries with a high value to respond more

[32] Adrian and Shin (2008) hypothesise that the combination of securitisation and market valuation affects the monetary transmission mechanism. Unfortunately, we are unable to test this hypothesis directly.

[33] This is suggested by the fact that they vary considerably between studies.

strongly to monetary policy shocks.[34] Again, we consider two groups containing those countries with the five highest and lowest values of the mortgage market index. Surprisingly, Figure 13 shows that neither the responses of GDP nor of residential property prices to monetary policy shocks differ between countries with a high and a low value of the index. A possible explanation is that some characteristics that make residential property prices more sensitive to monetary policy typically come together with other characteristics that have a partially offsetting effect. For instance, it may be that the ability to obtain a second mortgage dampens the responses of households in economies in which floating rate lending is prevalent.

6. Conclusions

In this paper we have studied the impact of monetary policy shocks on inflation, output and asset prices, using VARs and panel VARs estimated on quarterly data spanning 1986 to 2007. The analysis suggests several tentative conclusions regarding the ability of using monetary policy to "lean against" residential property price and stock price booms.

First, the panel VAR results show that monetary policy has large and predictable effects on residential property prices, and that these effects are roughly coincident with its effect on real economic activity. More precisely, 25 basis points increase in short-term interest rates depresses real GDP by about 0.125%, and real residential property prices by about three times as much, or 0.375%, after one or two years.

While these results suggest that monetary policy could potentially be used to slow down property price booms, the estimates imply that substantial interest rate increases would be necessary to do so and that these increases would depress real GDP considerably. For instance, a 250 basis point increase in interest rates would depress residential property prices by about 3.75% and real GDP by about 1.25%. Given that episodes of property price upswings have generally been associated with movements in prices of 15-20%, one is led to conclude that the cost of using monetary policy to slow down asset-price movements in order to reduce threats to financial stability might be large in terms of real output.

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[34] Since Switzerland is missing from the IMF study, we construct the index for Switzerland following the description in IMF (2008), footnote 3. The resulting index value of 0.26 implies that Switzerland is in the country group with less flexible mortgage markets.

Of course, it is possible that the impact on real property prices might be larger relative to real GDP than the three-to-one ratio we estimate here. But even if they are much larger, say five-to-one, the impact on real economic activity of an attempt to depress residential property prices are nevertheless likely to be pronounced.[35]

Second, the estimates also indicate that monetary policy shocks depress equity prices by about as much as they reduce residential property prices. However, equity prices decline immediately in this case and have returned to the initial level by the time residential property prices reach their through. As a consequence of this difference in timing, it is not possible to use monetary to stabilise both residential property and equity prices.

Third, the individual-country VAR estimates are highly imprecise. This may reflect an inherent shortcoming of VAR analysis: with a large number of parameters the estimates are necessarily subject to considerable uncertainty. If so, a central bank that is persuaded that policy can and should be used to influence asset prices could proceed despite the evidence to the contrary. Another interpretation, more plausible to us and compatible with the arguments of Kohn (2006), is that the impact of monetary policy on asset prices is in fact highly uncertain, suggesting that central banks might wish to refrain from attempting to steer asset prices.

Overall, we therefore interpret our results as suggesting that the proponents of using monetary policy to lean against asset-price fluctuations in order to ensure financial stability may have been too hasty to conclude that this is a sensible strategy.

Finally, our panel VAR analysis of the different subgroups of countries indicate that while the effects of monetary policy on residential property prices do appear influenced by the financial structure, the differences are not very large. One caveat, however, is that changes in financial structure might have occurred at different points in time in the countries in the two groups, blurring the results. Moreover, it is possible that better data on financial structure may lead us to have to revise this conclusion. But it is also possible that such data will lead us to conclude that one aspect of financial structure that seems to increase the economy's

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[35] Jarocinski and Smets (2008) estimate a five-to-one relation in a VAR model for the US. They obtain a GDP reaction of 0.1% to a 25 basis points monetary policy shock, which is close to our estimate of 0.125%.

sensitivity to monetary policy may be partially offset by another, reducing the overall differences between economies.

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Table 1. Unit-root test results

Levels	CPI	GDP	Interest rate	Prop. price	Equity price
Australia	-3.20	-1.92	-1.33	-2.00	-1.76
Belgium	-2.19	-3.09	-1.26	-1.23	-2.63
Canada	-2.82	-2.17	-1.62	-0.93	-2.54
Denmark	**-4.05**	-2.40	-1.57	-2.22	-2.79
Finland	-3.76	-2.36	-1.28	-2.26	-2.74
France	-2.30	-2.62	-1.36	-2.05	-2.68
Germany	-2.19	-2.80	-2.02	-1.62	-2.38
Ireland	-1.08	-1.60	-1.72	-1.86	-2.43
Italy	-2.44	-2.64	-1.05	**-4.50**	-3.09
Japan	-2.11	**-4.00**	-1.29	-2.58	-1.96
Netherlands	-2.53	-2.02	-1.67	-2.16	-1.99
Norway	**-4.32**	-2.52	-2.06	-3.18	-2.55
Spain	-2.43	-1.69	-2.38	-2.43	-2.65
Sweden	-3.36	-1.42	-1.13	-1.99	-2.46
Switzerland	-2.48	-1.61	-1.63	-1.70	-2.04
UK	-2.71	-3.06	-1.57	-1.58	-1.63
US	-2.77	-2.21	-2.33	-1.84	-2.01
IPS	**-3.19**	-1.17	-0.51	0.04	-1.23
1st diff.	CPI	GDP	Interest rate	Prop. price	Equity price
Australia	-2.99	**-4.38**	**-4.25**	**-3.10**	**-6.19**
Belgium	**-3.13**	**-5.11**	**-3.57**	**-3.20**	**-3.59**
Canada	**-3.44**	**-3.24**	**-4.27**	**-3.29**	**-5.27**
Denmark	-2.41	**-4.37**	**-4.83**	**-4.15**	**-4.39**
Finland	-1.81	-2.34	**-3.95**	**-3.04**	**-3.26**
France	-2.70	**-3.50**	**-4.10**	-1.97	**-4.26**
Germany	-2.64	**-3.35**	**-2.96**	-2.72	**-4.20**
Ireland	**-3.52**	**-5.36**	**-4.95**	**-3.04**	**-4.08**
Italy	-1.69	**-4.10**	**-3.97**	-1.67	**-3.41**
Japan	-2.50	**-3.10**	**-3.23**	-2.31	**-4.87**
Netherlands	**-3.71**	**-5.27**	**-3.36**	-2.71	**-3.38**
Norway	**-4.07**	**-4.48**	**-4.04**	**-3.97**	**-4.30**
Spain	-2.13	**-3.24**	**-5.41**	-2.63	**-3.81**
Sweden	-2.21	**-4.26**	**-3.84**	-2.72	**-3.87**
Switzerland	-2.13	**-4.25**	**-3.69**	-2.70	**-4.00**
UK	-1.76	-2.29	**-3.31**	**-3.27**	**-4.20**
US	**-2.90**	**-3.56**	**-3.83**	-2.35	**-4.24**
IPS	**-5.57**	**-11.25**	**-11.96**	**-6.43**	**-12.69**

Note: IPS is the Im, Pesaran and Shin (2003) test. Except for the interest rate, where we include a constant only, the tests for the levels include a constant and a trend and four lags, whereas the test for the differences include a constant and three lags. Critical values for the ADF tests are -3.44 for the test with trend and -2.89 for the tests including only a constant. The IPS test statistics are distributed as N(0,1). Bold face denotes significance at the 5 percent level.

Table 2. Characteristics of mortgage markets

	Interest rate adjustment	Mortgage equity withdrawal	Average loan-to-value ratio (%)	Mortgage–debt-to-GDP ratio (%)	Valuation method	Mortgage-backed securitisation	Owner occupation share (%)	IMF mortgage market index
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Australia	Variable	Yes	90-100	74	Market value	Yes	70	0.69
Belgium	Fixed	No	80-85	31	Market value	No	72	0.34
Canada	Fixed	Unused	70-80	43	Lending value	Yes	66	0.57
Denmark	Fixed	Yes	80	67	Market value	No	59	0.82
Finland	Variable	Yes	75-80	40	Market value	Limited	64	0.49
France	Fixed	No	80	26	Market value	Limited	56	0.23
Germany	Fixed	No	70	52	Lending value	Limited	42	0.28
Ireland	Variable	Yes	60-70	53	Market value	Limited	78	0.39
Italy	Fixed	No	50	15	Market value	No	80	0.26
Japan	Fixed	Yes	80	36	Market value	No	61	0.39
Netherlands	Fixed	Yes	112	111	Market value	Yes	53	0.71
Norway	Variable	Yes	70	63	Market value	No	77	0.59
Spain	Variable	Unused	80	46	Market value	Yes	85	0.40
Sweden	Variable	Yes	80-90	54	Market value	Limited	61	0.66
Switzerland	Variable	No	66	128	Lending value	Limited	36	0.26
UK	Variable	Yes	70	73	Market value	Yes	70	0.58
US	Fixed	Yes	80	69	Market value	Yes	69	0.98

Note: Columns (1), (2), (5) and (6) are from Tsatsaronis and Zhu (2004), columns (3), (4) and (7) are from Calza et al. (2007), with information for Norway and Sweden taken from Ahearne et al. (2005) and for Switzerland from CGFS (2006). For column (8) see IMF (2008), own calculations for Switzerland.

Figure 1. Log residential property prices in levels and changes relative to the same quarter of the previous year

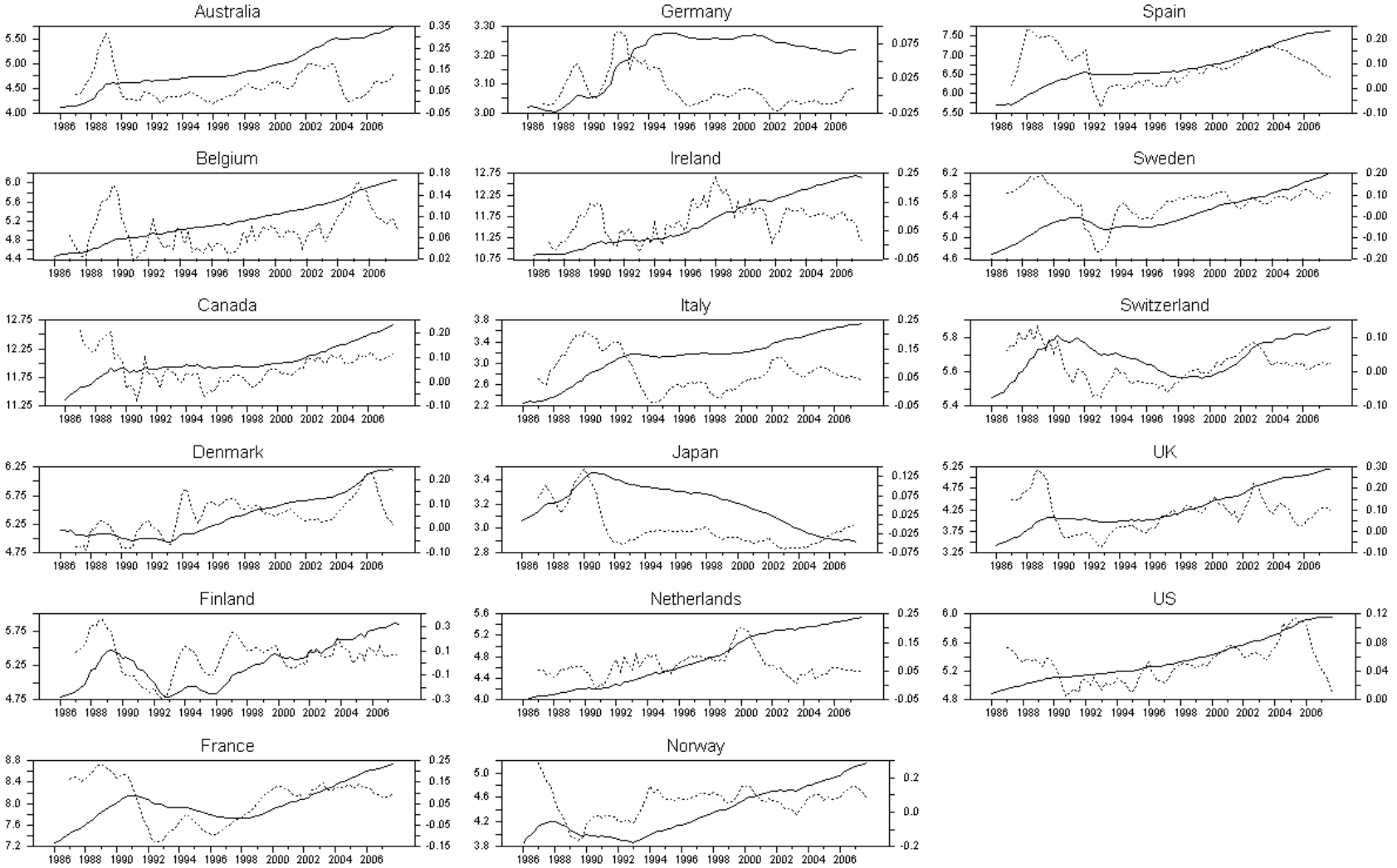


Figure 2. Annual property-price growth rates for subcategories

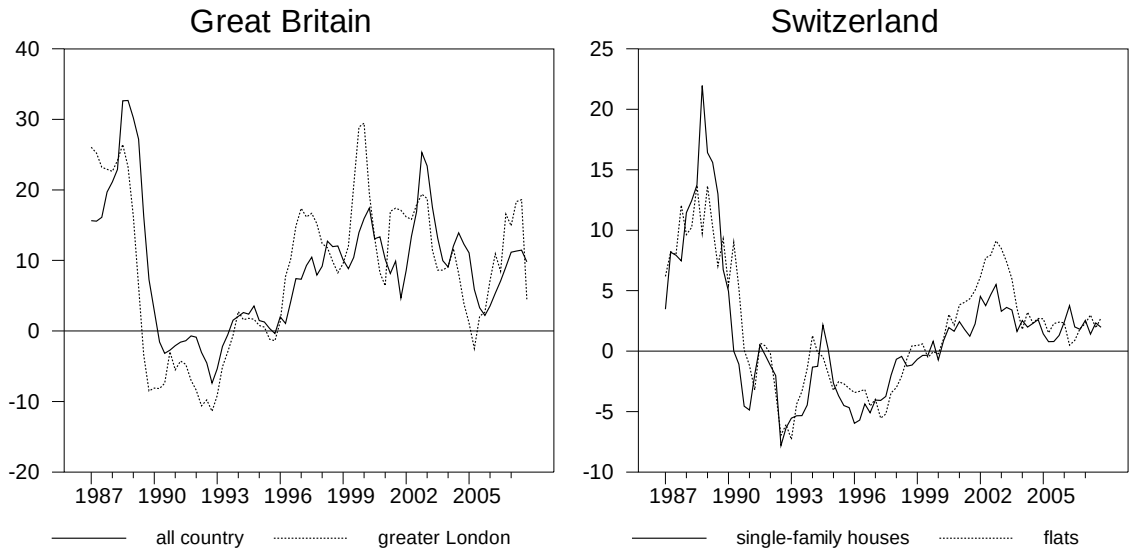


Figure 3. Impulse responses to a 25 basis point monetary policy shock

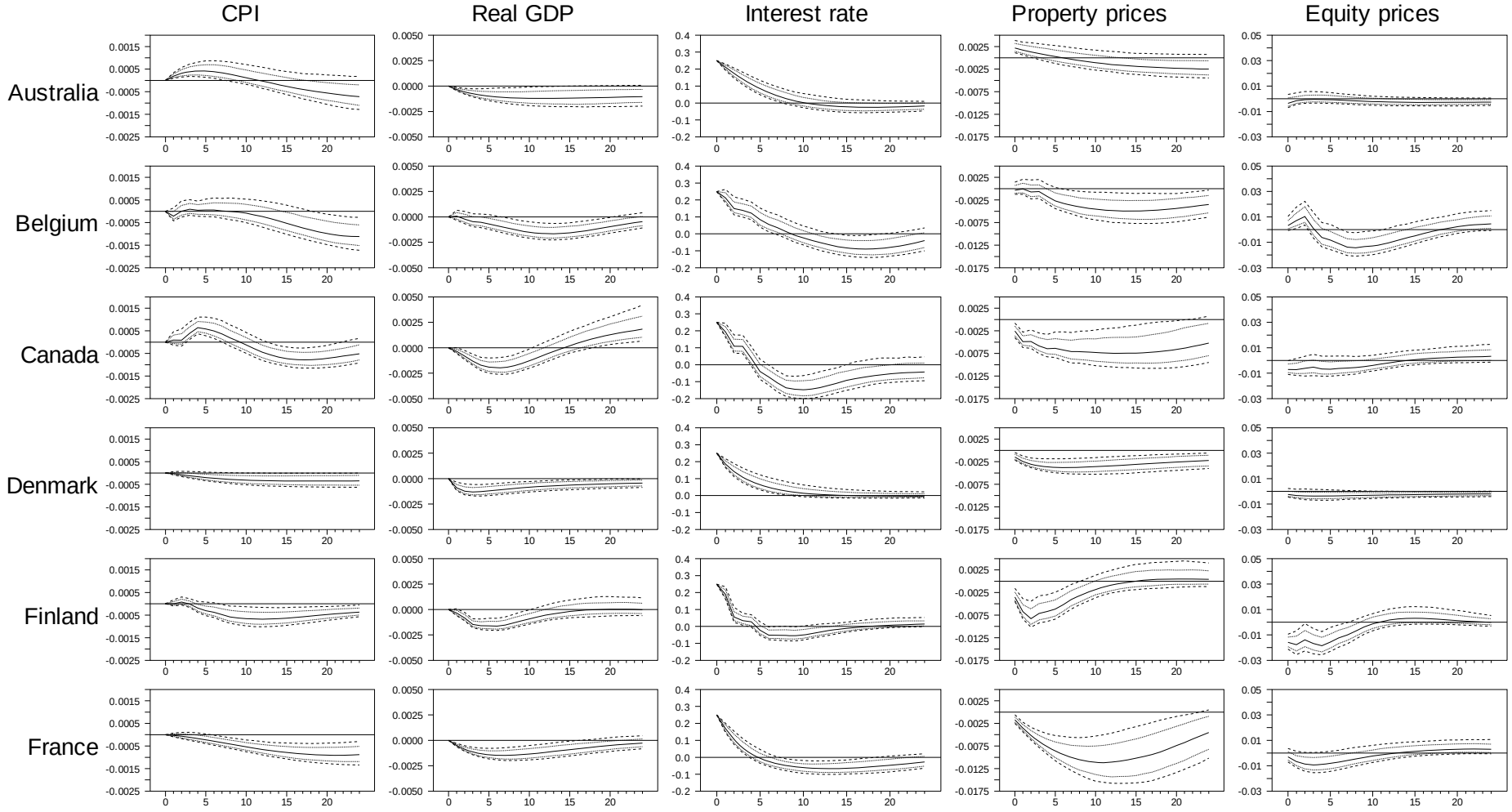


Figure 3 (cont.): Impulse responses to a 25 basis point monetary policy shock

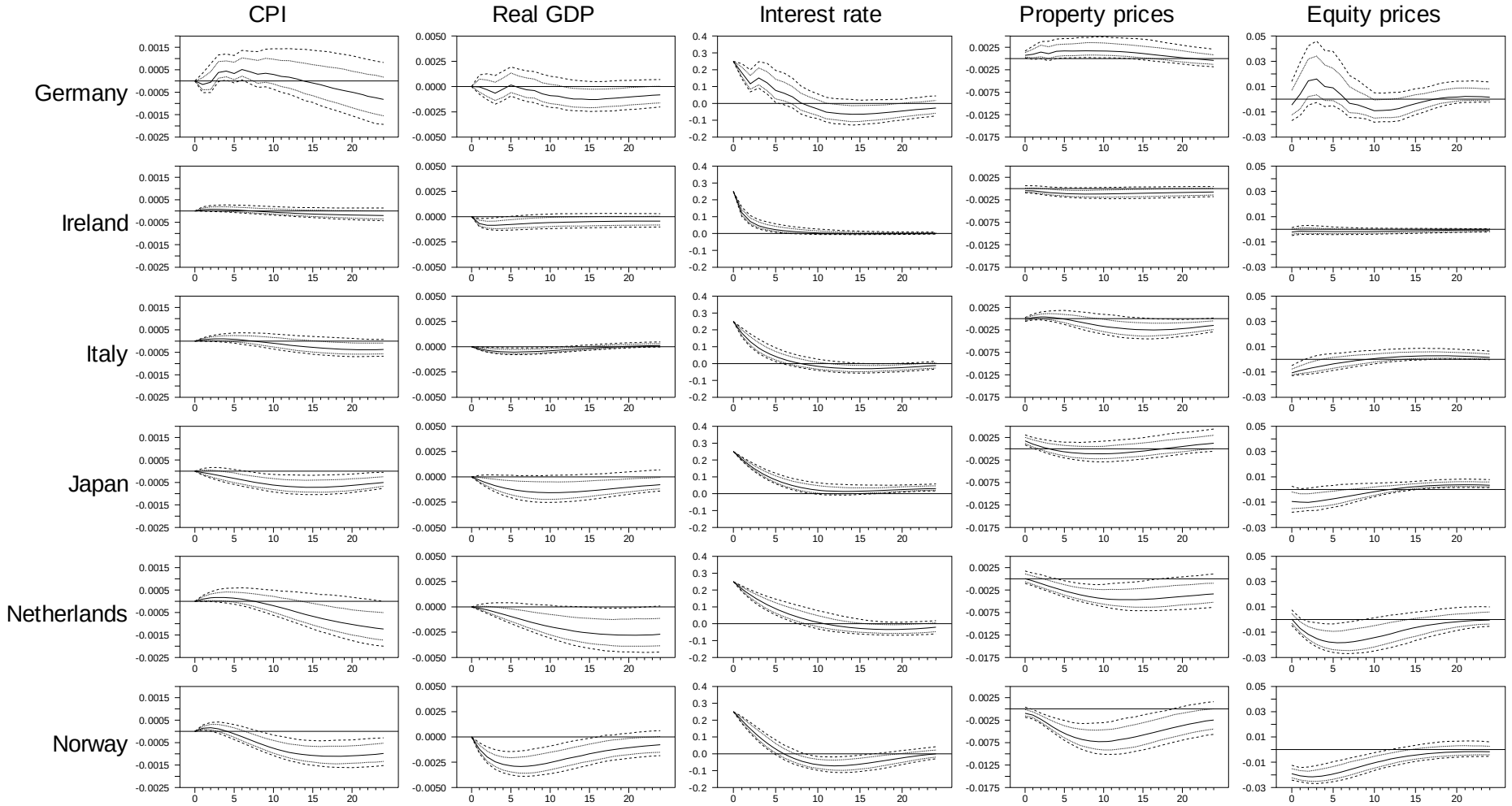
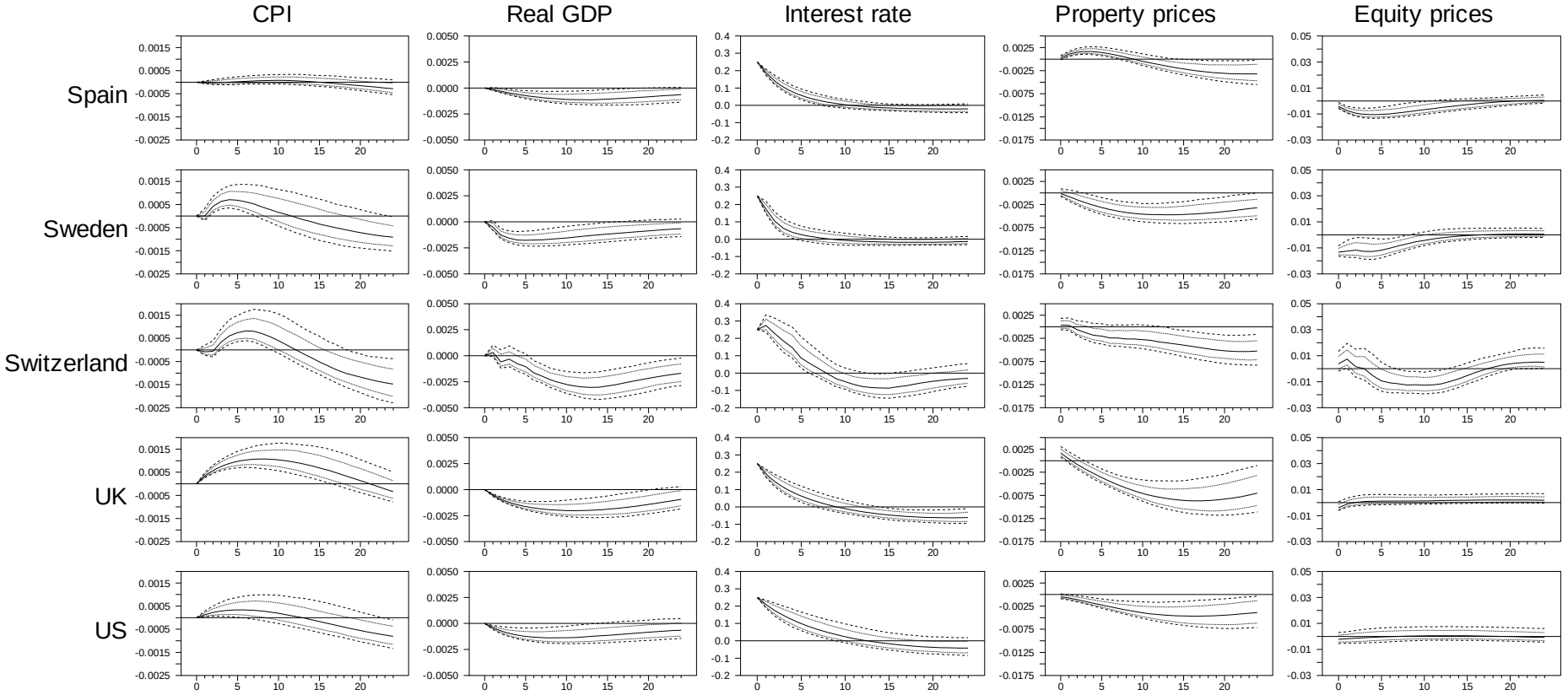
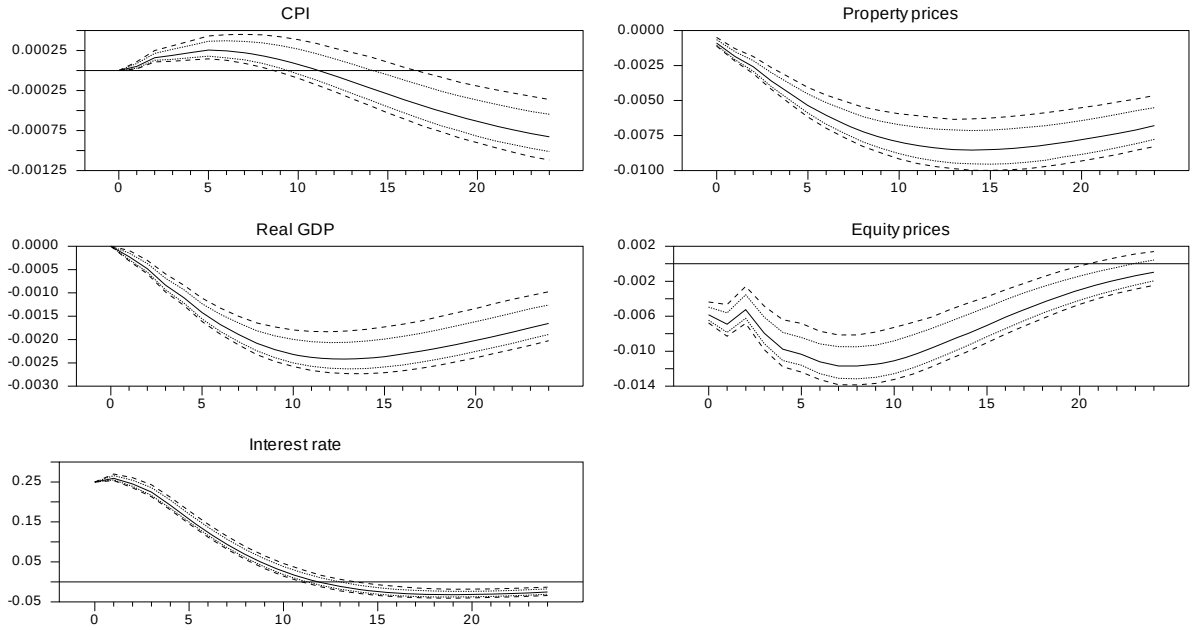


Figure 3 (cont.): Impulse responses to a 25 basis point monetary policy shock



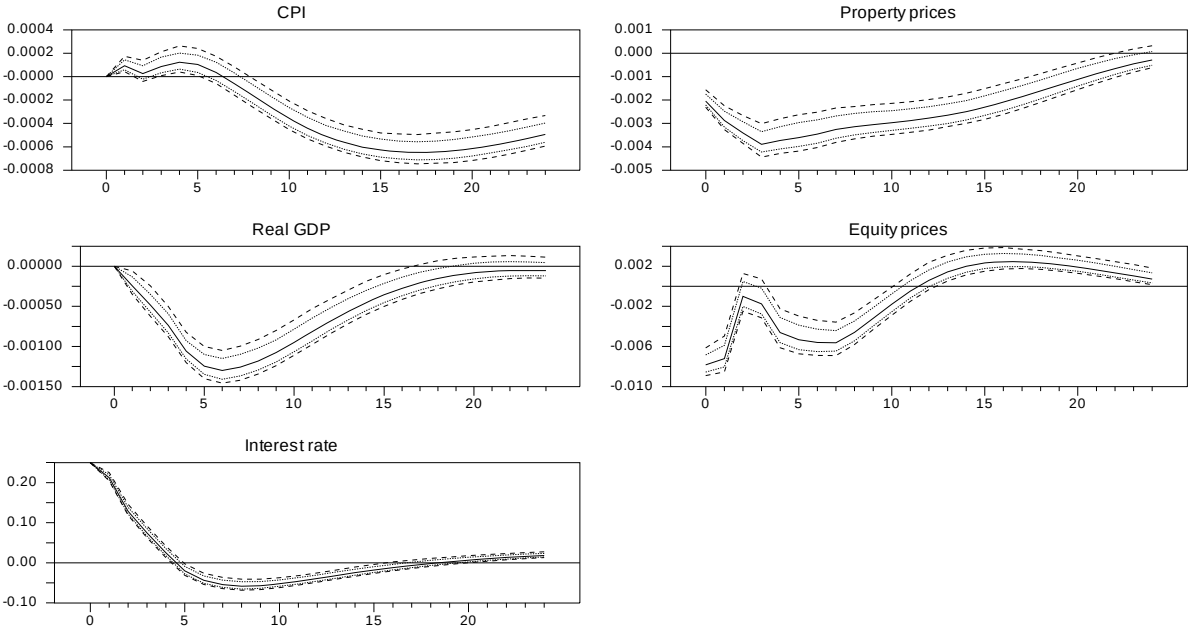
Note: The solid line is the bootstrapped median impulse response. Long dashes indicate two-standard-error, short dashes one-standard error confidence bands. Results are based on 1000 bootstrap replications.

Figure 4. Impulse responses to a 25 basis point monetary policy shock in panel VAR with fixed-effects estimator



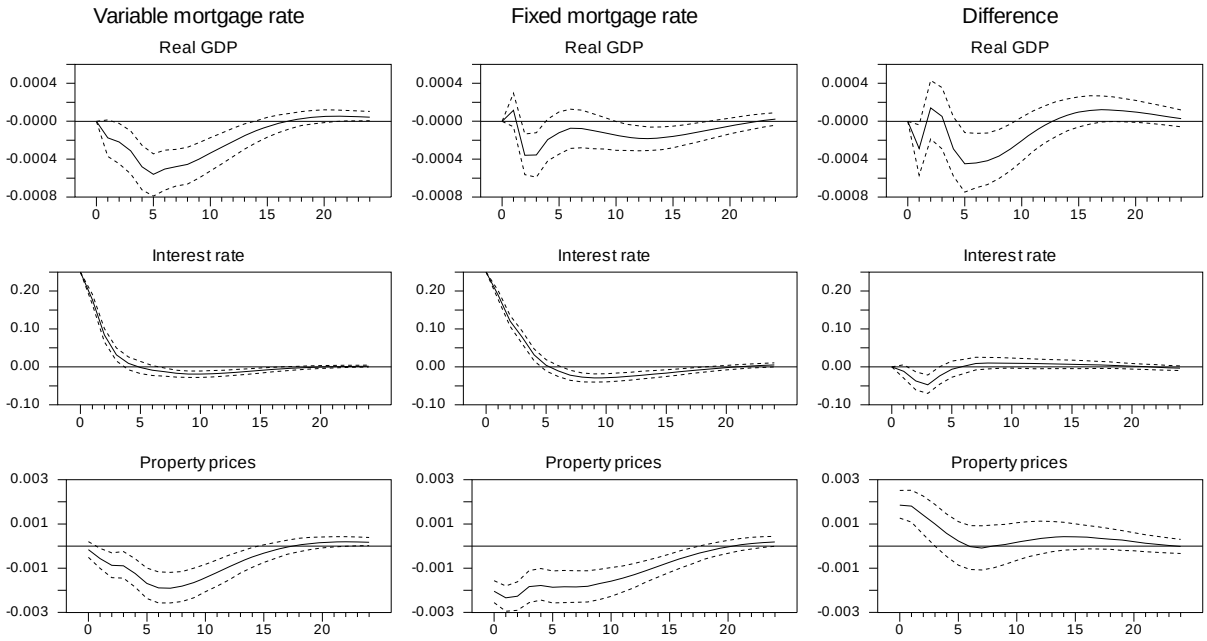
Note: See note to Figure 3.

Figure 5. Impulse responses to a 25 basis point monetary policy shock in panel VAR with mean-group estimator



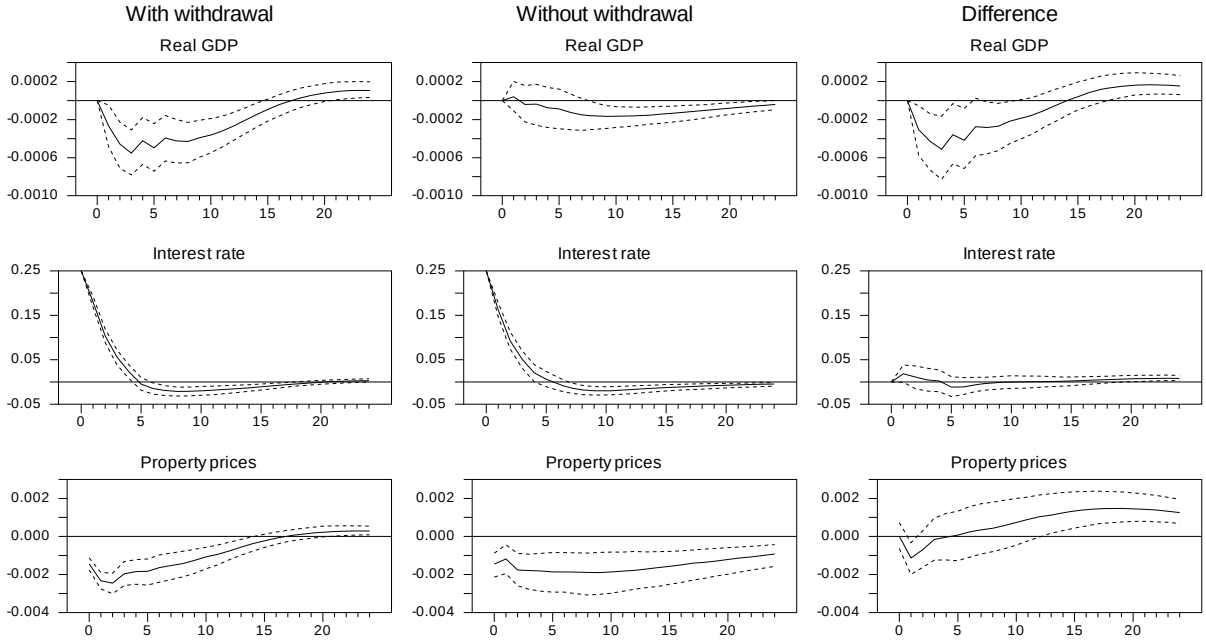
Note: See note to Figure 3.

Figure 6. Panel VAR split with respect to mortgage rate



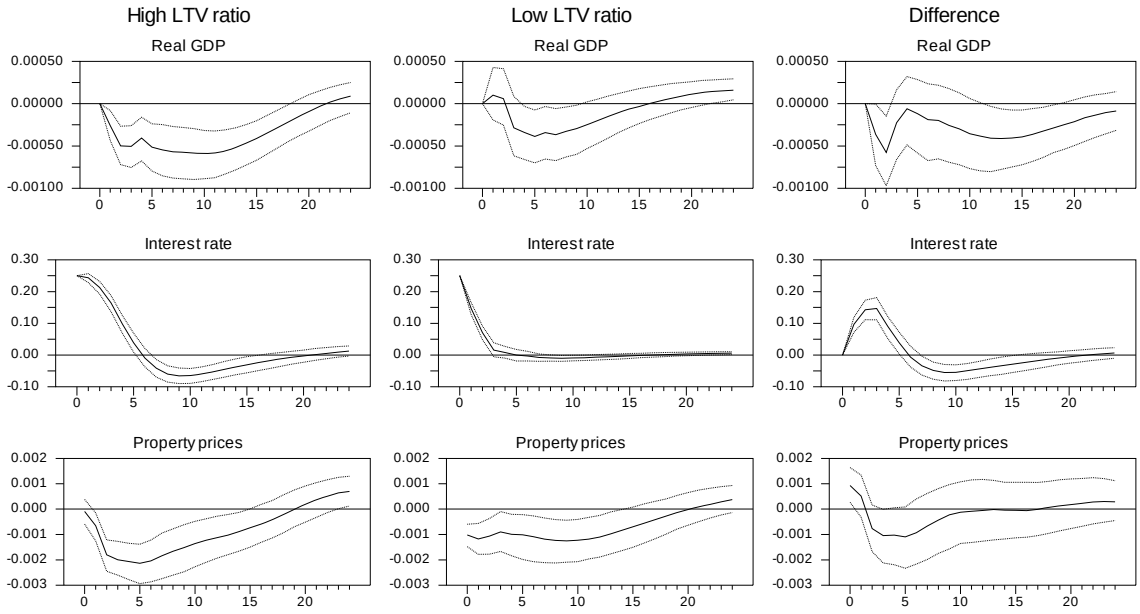
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications. The country grouping is indicated in Table 2.

Figure 7. Panel VAR split with respect to mortgage equity withdrawal



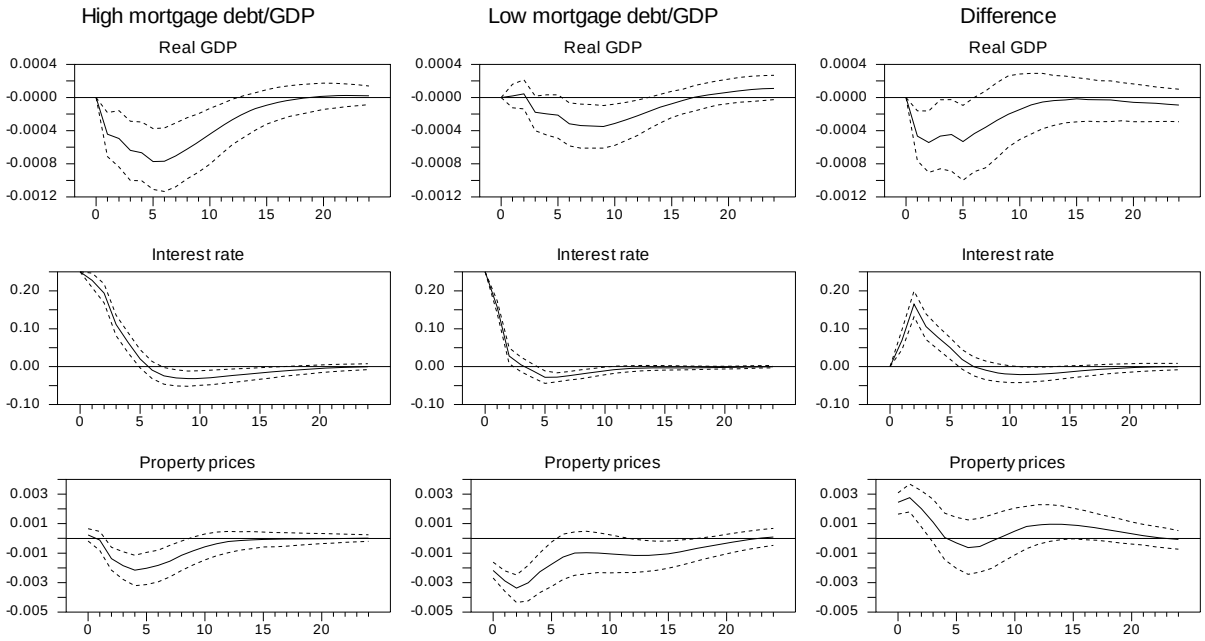
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications. The country grouping is indicated in Table 2, with Canada and Spain excluded from the sample.

Figure 8. Panel VAR split with respect to loan-to-value ratio



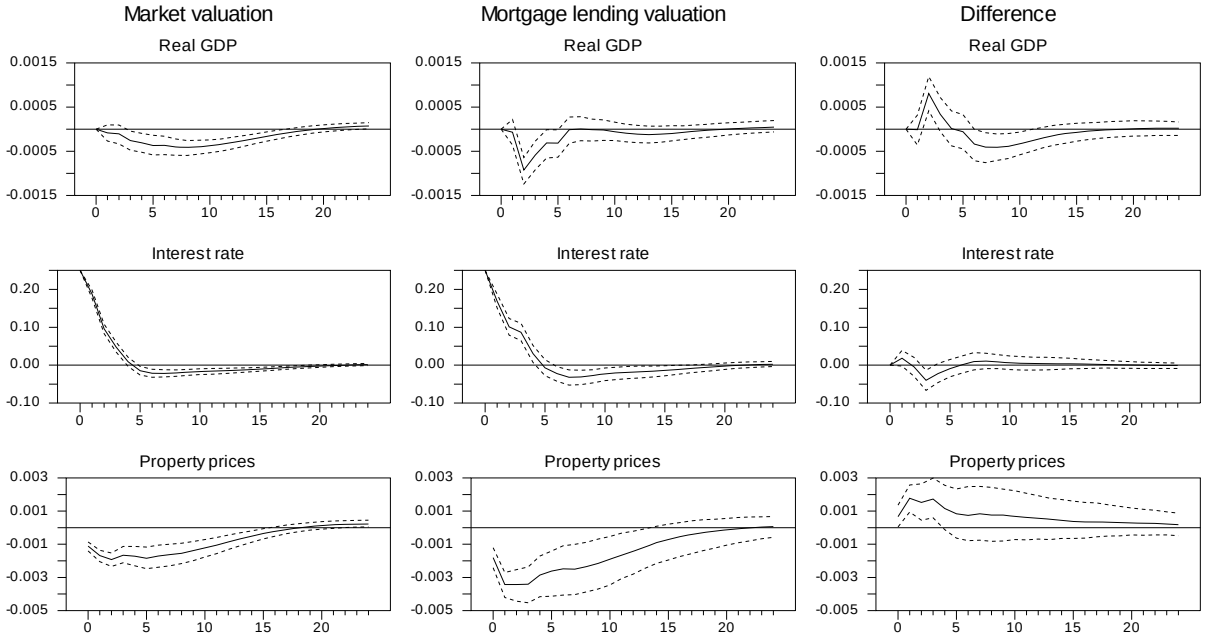
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. Australia, Belgium, the Netherlands and Sweden belong to the first group, Germany, Ireland, Italy, Norway, Switzerland and the UK to the second.

Figure 9. Panel VAR split with respect to mortgage-debt-to-GDP ratio



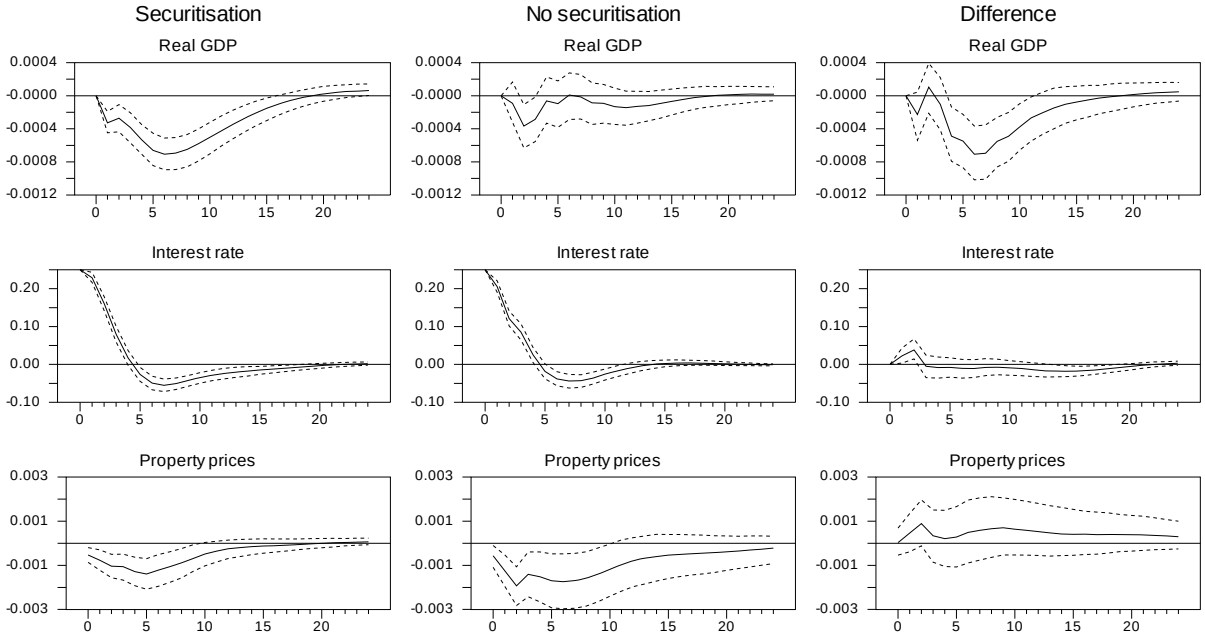
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. Australia, the Netherlands, Switzerland, the UK and the US belong to the first group, Belgium, Finland, France, Italy and Japan to the second.

Figure 10. Panel VAR split with respect to valuation method



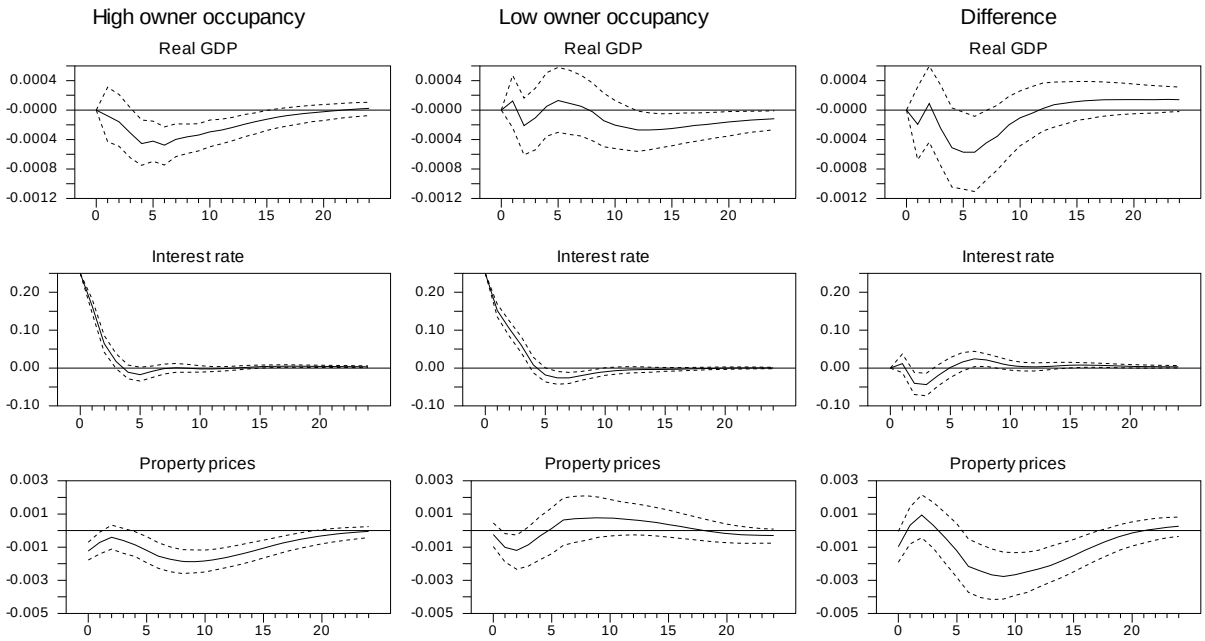
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. The country grouping is indicated in Table 2.

Figure 11. Panel VAR split with respect to securitisation.



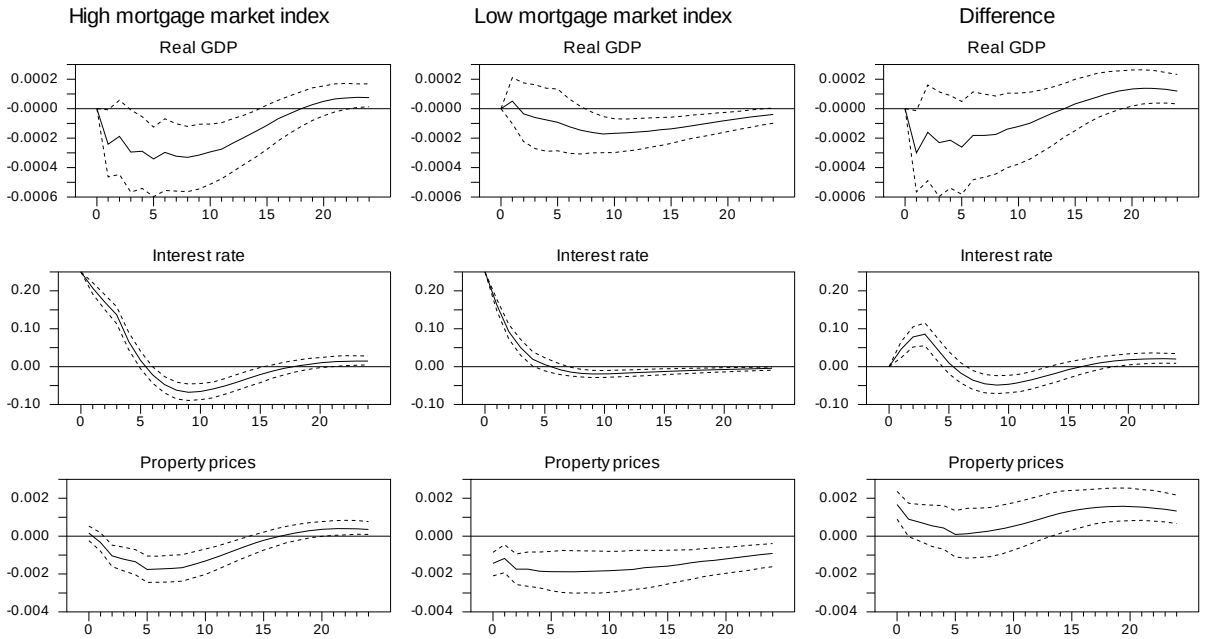
Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. The first group includes Australia, Canada, the Netherlands, Spain, the US and the UK, the second group Belgium, Denmark, Italy, Japan and Norway.

Figure 12. Panel VAR split with respect to owner occupancy



Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. Belgium, Ireland, Italy, Norway and Spain belong to the first group, Denmark, France, Germany, the Netherlands and Switzerland to the second.

Figure 13. Panel VAR split according mortgage market index



Note: The solid line is the bootstrapped median impulse response, the dashed lines the one-standard-error confidence bands. Results are based on 1000 bootstrap replications.. Countries in the first group include Australia, Canada, Denmark, Finland, the Netherlands, Norway, Sweden, the UK and the US; countries in the second group are Belgium, France, Germany, Ireland, Italy, Japan Spain, and Switzerland.