Monetary Policy, Asset Prices and Macroeconomic Conditions: A Panel-VAR Study

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Abstract

This paper studies the relationships between inflation, economic activity, credit, monetary policy, and residential property and equity prices in 17 OECD countries, using quarterly data for 1986-2006. Using a panel VAR, we find plausible and significant responses to a monetary policy shock. Shocks to asset prices have a positive, significant effect on GDP and credit after three to four quarters, whereas prices start to increase much later. We also consider the transmission of US shocks from the US to the other economies. While monetary policy shocks are transmitted internationally, other shocks are not, perhaps because of the form of coefficient restrictions used.

Keywords: asset prices, credit, monetary policy, panel VAR.

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1. Introduction

Rapid and sustained credit growth coupled with large and protracted increases in asset prices, in particular in residential property prices, have played a central role in all too many episodes of financial instability.[1] The story, argue many, is one and the same: for whatever reason, the economy enters a boom and credit growth starts to rise. With growing incomes and credit easily available, the demand for housing expands and residential property prices rise, as do a range of other asset prices. After some time, the process takes on a life of its own, with property prices becoming increasingly disconnected from any reasonable measure of their equilibrium level, sustained by a large and easily identifiable bulge in credit. As the process continues and borrowers become more and more overextended, their sensitivity to macroeconomic conditions, including to the cost and availability of credit, rises. A small shock can then trigger the process to work in reverse, ending with a collapse in property prices and in credit growth and, perhaps, many years of macroeconomic weakness and financial instability.

Proponents of this view hold central banks squarely responsible for the property and credit "bubbles" and their aftermath. By running a too expansionary monetary policy for too long and, in particular, by disregarding the "excesses" in property and mortgage markets, the argument goes, monetary policy makers enable the process of expansion and collapse to run its course. A better policy, it is asserted, would be for central banks to "lean against" asset price bubbles by tightening monetary policy somewhat when asset prices rise too strongly and, presumably, relax policy when asset prices fall. Importantly, this reaction should be "over and beyond" what changes in asset prices imply for the path of aggregate demand and inflation (Borio and Lowe 2002, Cecchetti et al. 2000).

There is little doubt that this view of the dynamics of asset price booms and busts is broadly compatible with observed movements in income, credit, interest rates and asset prices. However, that does not mean that it is correct: Macroeconomic time series typically display strong co-movements and are jointly determined endogenous variables. As a consequence, it is frequently possible to think of several explanations for the observed correlations (e.g.

[1] See for instance Ahearne et al. (2005) or Goodhart and Hofmann (2007, 2008) and the contributions in Hunter et al. (2003).

Goodhart and Hofmann 2008). These explanations have sometimes very different policy implications.

For instance, consider the strong correlation between credit growth and asset prices changes. One view is that too lax monetary policy triggers rapid credit growth and a property-price bubble in which actual and equilibrium prices diverge. This is a story of loose monetary policy leading to temporary disequilibria ("excesses"), and unavoidable and painful "corrections." Another interpretation of this correlation is that well-warranted expectations of rising future income and the associated demand for housing leads to equilibrium prices for property to rise, and to a greater demand for credit. Unexpected economic developments may subsequently lead to reduced income expectations, declining demand for housing, lower equilibrium housing prices and falling credit demand. Under this view, any attempt by central banks to cool property markets will push prices *below* their equilibrium levels, and presumably output and inflation too, and thus worsen economic outcomes.[2]

Another example is the correlation between low short-term real interest rates and rising asset prices that we see in the data. Since asset prices depend on the discounted value of future earnings, a persistent decline in the real interest rate should be associated with rising asset prices. Furthermore, since inflation rates are sluggish, it is clear that central banks' control over *short-term nominal* interest rates allows them to influence real interest rates temporarily. But it is much less clear that they can influence the *long-term real* interest rates that theory suggests are important determinants of asset prices. Thus, the correlation between short real interest rates and asset prices that we observe in the data does not necessarily imply that excessively expansionary monetary policy has caused asset price increases. Rather, it may be that a decline in long real interest rates (the "conundrum") have led to rising asset prices, and have separately caused central banks to reduce short-term nominal rates.[3] If so, the

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[2] Gerlach and Peng (2005) consider the correlations between credit and property prices in Hong Kong, which has experienced exceptionally strong swings in asset prices and credit in recent decades. They argue that the data suggest that changing expectations of future growth induce changes in demand for property and therefore in the demand for credit. Hofmann (2003) provides a cross-country analysis that suggests that credit seems to play largely an accommodating role in property-price cycles in many countries.

[3] One reason for that could be that if the equilibrium real interest rate falls, central banks have little choice but to cut interest rates since otherwise inflation would fall and economic activity slow.

correlation between short-term interest rates and asset prices may be caused entirely by a third variable.

The endogeneity and strong correlations between macroeconomic variables suggests to us that more work, empirical and theoretical, on understanding the joint behaviour of credit and asset prices, short-term nominal interest rates (as measures of the stance of monetary policy) and broad macroeconomic conditions is warranted.

This paper seeks to contribute to the empirical dimension of this research agenda by shedding light on the relationship between inflation, economic activity, credit, the stance of monetary policy, and residential-property and equity prices in 17 OECD countries using quarterly data for the period 1986-2006. Rather than analysing the behaviour in individual countries – an exercise which is bound to generate a sea of results which will be difficult to reconcile and summarise – we follow Goodhart and Hofmann (2008) who use panel VAR techniques to better understand the correlations in the data.[4]

One important aspect of the current financial crisis is that property prices across the world have started to fall following the onset of the subprime mortgage crisis in the US or, arguably more precisely, the events that led to it.[5] Furthermore, it is commonly felt that shocks and economic disturbances in the US have a disproportionately large impact on economic developments elsewhere. With data for the US and sixteen other countries, our data set is an obvious starting point for exploring these issues. We therefore also exploit the cross country dimension of our data set and study the transmission of shocks originating in the US to the other countries in our sample. While the estimates are interesting in their own right, the purpose of this research agenda is to establish empirical regularities, which are summarised in the impulse response functions, that future theoretical models must be able to account for.

The paper is organised as follows. The next section contains a discussion of the data. In Section 3 we present our empirical framework. Section 4 discusses the impulse responses to various shocks in a panel VAR, whereas Section 5 investigates the international transmission of such shocks from the US to other industrial countries. Finally, Section 6 concludes.

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4 See also the discussion in Assenmacher-Wesche and Gerlach (2008b).

5 For a discussion of this episode, see Gerardi et al. (2008).

2. Data

The econometric work reported below is conducted on quarterly data on consumer prices (*p*), real GDP (*y*), credit (*cr*), three-month interest rates (*i*), residential property prices (*pp*) and equity prices (*ep*). Except for the interest rate, all variables are in logarithms.[6] Much of the interest in the behaviour and determination of asset prices stems from their role in episodes of financial instability. Since there is thus a natural tendency to focus on data from countries that have experienced pronounced asset-price swings, there is a risk of sample selection bias. To mitigate the risk of that, we follow Goodhart and Hofmann (2008) and consider as broad a panel as possible. As they do, we 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.

While we use data similar to those studied by Goodhart and Hofmann (2008), there are some differences between their analysis and ours. First, we include equity prices in the analysis. While residential property certainly is of importance, stock markets have also undergone bubble-like episodes and are therefore of concern to policy makers. Second, because the policy discussions usually are framed in terms of credit rather than monetary aggregates, we do not include money as they do. This prevents the system from getting too large and facilitates the identification of the structural disturbances since it is difficult to disentangle money and credit shocks. Third, we estimate the panel VAR in levels instead of in first differences. Since we find evidence of cointegration between the variables in the VAR, estimation in first differences is inefficient because it neglects the information contained in the levels of the different time series.

Fourth, we use the mean-group estimator proposed by Pesaran and Smith (1995) instead of the standard fixed effects panel estimator to estimate the panel VAR and to study the "average" responses of these economies to shocks. One attractive feature of this estimator is that it does not require us to assume that the economic structures of the countries in the

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

panel are the same.[7] Such heterogeneity, if disregarded in estimation, will bias the estimates underlying the VARs. In particular, it is likely to lead to implausible estimates of the persistence of shocks.[8]

The sample starts in 1986 and ends in 2006. This choice of sample avoids the more turbulent period with high and variable inflation that ended in the first half of the 1980. Furthermore, many countries deregulated their mortgage markets during the first half of the 1980s which suggests that that estimates relying on older data may not be representative. [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 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

7 In previous work (Assenmacher-Wesche and Gerlach 2008b) we explored whether differences in financial structure could explain differences in the monetary transmission mechanism, using the present data, but found little evidence in support of that hypothesis. One reason for that may be that other factors, such as the wage-setting mechanism and the structure of the economy, play much more important roles in account for international differences in the transmission mechanism. Goodhart and Hofmann (2008) formally test, and reject, the hypothesis that the parameters in the PVAR they estimate are the same across countries.

8 This is clear from comparing the estimated impulse responses functions in Assenmacher-Wesche and Gerlach (2008a), which uses the fixed effect estimator, with those in Assenmacher-Wesche and Gerlach (2008b), which does not.

9 See Ahearne et al. (2005) and Girouard and Blöndal (2001),

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

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

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]

Before proceeding, we emphasise that the data on residential property prices are not necessarily comparable across countries (see Arthur 2005 or Assenmacher-Wesche and Gerlach 2008b). For our study we use whenever possible the broadest residential property price index available to reduce the risk that regional developments contaminate the data. 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), share price indices (all shares) and the credit data 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.[14] 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.

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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 For the Netherlands the IFS data apparently contain an error in 1998. We therefore used real GDP from the MEI data base.

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.

Figure 1 shows the resulting residential property price series, together with the credit volume.[16] The graphs show that 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. The figure also shows that two countries stand out against this general pattern. In Japan, the "bubble economy" collapsed around 1990, after which residential property prices fell continuously until the end of the sample. In Germany residential property prices started falling in the mid 1990s and also declined until the end of the sample, vividly indicating the adverse macroeconomic developments in Germany in the last decade or two.

Interestingly, while the graphs show that property prices and credit both grow over time, the linkages between these variables appear in many cases to be low (e.g. Finland, Germany or Switzerland).[17] In those countries showing pronounced property-price swings (e.g., Finland, Norway or Sweden), turning points in credit generally *follow* those in real property prices. While this finding may be due to the fact that these plots disregard movements in other variables, in particular real GDP and interest rates, they cast doubt on the notion that movements in credit are good signals of future changes in property prices as suggested by many.[18] If anything, the graphs suggest that the opposite is more likely to be the case.[19] Nevertheless, it is clear that credit is an important variable that provides a link through which changes in asset prices may impact on the financial sector and the real economy.

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16 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).

17 Although we plot the level of nominal property prices, which arguably should have a close relation to nominal credit and show non-stationary behaviour, the correlation coefficient for the annual growth rates of the series is below 0.5 for several countries.

18 See for instance the discussion in Borio and Lowe (2002).

19 See also Gerlach and Peng (2005) and Hofmann (2003).

In Figure 2 we plot the first difference of the changes in property prices. The figure shows that in many countries (including in France, Italy Sweden, Switzerland and the UK), the average rate of increase of property prices was high in the late 1980s, low in the early 1990s, and higher again around the turn of millennium. These gradual fluctuations in the growth rate suggest that property prices are I(2) processes, that is, they need to be differenced twice to become stationary. Indeed formal unit-root tests for property prices reported in Table 1 reject the hypothesis that they are I(1). Though credit and the CPI also show evidence of I(2)-like behaviour in some countries, we decided to treat these variables as I(1) since they are stationary elsewhere.[20] Since we could not reject the presence of cointegration, we specify the VAR models in the level of the variables.[21] Since property prices seem to be I(2), the growth rate, as opposed to the level, of property prices should enter in our model.[22]

3. Methodology

The effects of economic disturbances frequently spill over to other countries. When studying the issues at hand, it is therefore desirable to use an econometric framework that allows us investigate also the international transmission of such shocks. While until recently it has been impossible to estimate large VAR systems, techniques are now available to deal with the huge number of coefficients in such systems. The methodology we use is a restricted version of the multi-country VAR modelling approach put forth by Canova and Ciccarelli (2006).[23] As a starting point, consider a multi-country VAR where each equation contains lagged values of all variables in all countries.

In its most general form this model can be written as

$$y_{n,t} = \mu_n + A_n(L)Y_{n,t-1} + \varepsilon_{n,t}, \qquad (1)$$

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[20] Furthermore, if the CPI is regarded as I(2), we obtain a price puzzle in the response to a monetary policy shock.

[21] Nevertheless, we neither impose the number of cointegrating relations on the systems nor do we attempt to impose overidentifying restrictions on the cointegrating vector.

[22] Indeed, estimates using the level of property prices led to several oddities in the estimated impulse response functions.

[23] The GVAR methodology introduced by Pesaran, Schürmann and Weiner (2004) and further developed in Dees et al. (2006) is another possible approach to estimating multi-country VARs. Dees et al. (2006) discuss the similarities of the GVAR approach with a factor VAR model.

where $y_{n,t}$ is a $k \times 1$ vector of variables of each of the N countries, n = 1, … N. $Y_{n,t} = (y'_{1,t}, y'_{2,t}, \ldots, y'_{N,t})$ collects the data for all countries, μ_n is a country-specific intercept and $A_n(L)$ is a lag polynomial with the VAR coefficients. The disturbances, $\varepsilon_{n,t}$, have zero means and a country-specific variance, σ_n^2. If the model were estimated without restrictions, the matrices A_n would have N x kN coefficients, leading to a total of 7038 coefficients in a VAR of order four with 17 countries and six variables. Of course, such a model is not estimable without imposing restrictions on the coefficients.

In this paper, we take two approaches. First, we neglect the international linkages between the countries, i.e. we restrict the coefficients on the foreign variables in $Y_{n,t}$ to zero. This corresponds to a conventional panel VAR setup, such as that used by Goodhart and Hofmann (2008). Second, we consider international linkages by reparameterizing the VAR following the suggestion by Canova and Ciccarelli (2006). While the dependent variables remain unchanged, the movements in the regressors are summarized by different linear combinations, which one can think of as "factors," of the explanatory variables. These factors capture the bulk of the variation in the data, but permit the model to be estimate with a greatly reduced number of regressors. We next discuss our panel VAR estimation setup for the domestic model, before we turn to the multi-country VAR.

3.1 Panel VARs

In contrast to Goodhart and Hofmann (2008) we do not use the standard fixed effect estimator, which is well known to be biased in panels that include 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.

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 countries. 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). In the present case, where all equations have lagged dependent variables and the regressors have close to unit roots, this problem can lead estimated impulse response functions to display extreme persistence. We therefore follow Pesaran and Smith's recommendation and estimate the PVAR using the mean group estimator. This estimator provides a consistent estimate of the mean effects by averaging the coefficients across countries.

The mean group estimator assumes that the coefficients in $A_n(L)$ vary randomly across countries and that the typical element $a_{n,i,j}^{p}$ in $A_n(L)$ can be written as $a_{n,i,j}^{p} = a_{i,j}^{p} + \eta_{n,i,j}^{p}$, where n is the country index, p = 1, …, P, the lag order of the VAR and i, j = 1, … K the number of variables in the VAR. We are interested in the means of the parameters, $a_{i,j}^{p}$ from N individual-country reduced-form VARs that can be written as $y_{n,t} = \mu_n + A_n(L) y_{n,t} + \varepsilon_{n,t}$, where, for reasons discussed in the next section, we have that $y_{n,t} = (p_{n,t}, y_{n,t}, cr_{n,t}, i_{n,t}, \Delta pp_{n,t}, ep_{n,t})$, 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. Since we use quarterly data we include four lags both in the PVAR and the multi-country VAR.

3.2 International VARs

To investigate the international transmission, however, we estimate the influence of US variables on the other economies in the panel, following Canova and Ciccarelli (2006). The assumption underlying the multi-country model is that the coefficients can be factored as

$$\delta = \sum_{f=1}^{F} \Xi_f \theta_f + u,$$

where each θ_f is of lower dimension than the full coefficient matrix δ, and the Ξ_f maps the right-hand-side variables of the VAR into these factors. Intuitively, one may think of the linear combinations of the variables as a more parsimonious representation of the information contained in the data. While in a standard VAR each variable is allowed to have an independent effect on the dependent variable, here the coefficients are restricted to be the same across certain dimensions of the data.[24]

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24 The GVAR methodology of Pesaran, Schürmann and Weiner (2004) takes a slightly different approach by allowing unrestricted coefficients for the domestic variables and imposing trade

For example, a typical element of δ, $\delta^{n,k,p}$, with *n* denoting the country, *k* the variable and *p* the lag, can be factored into

$$\delta^{n,k,p} = \theta_1 + \theta_2^n + \theta_3^k + \theta_4^p + u^{n,k,p},$$

where θ_1 captures all common movements and is constructed as the sum of all regressors.[25] The country-specific factor, θ_2, is a 17 *x* 1 vector capturing all country-specific variation and can be obtained by computing the sum over all variables and all lags for a specific country. The factor θ_3 takes account of variable specific movement by summing the same variables over all countries and lags. Finally, θ_4 reflects the lag-specific variability and is calculated as the sum over all variables and countries for a specific lag. Since the full set of the θ_i's sums to the common factor (like with a full set of dummies), we have to leave out one of the θ_i's when estimating the regressions. We thus have reduced the dimensionality of our VAR to (1 + 16 + 5 + 3) x 17 = 425 coefficients instead of the initial 7038 unrestricted estimates.

3.3 Identification

To identify the shocks, we use a Choleski decomposition, with the variables ordered as above. While it is standard in the monetary transmission literature to order output and prices before the interest rate (see Christiano et al. 1999), the inclusion of credit, property and equity prices warrants discussion. Our preferred ordering puts credit before the interest rate, whereas property and equity prices are ordered after the interest rate. By imposing a triangular identification structure we thus assume that output, the price level and credit react only with a lag to monetary policy shocks, whereas property and equity prices may respond immediately. The same reasoning applies to the other shocks in the system. For instance, while a shock to credit affects output and the price level only with a lag, the interest rate, property and equity prices can react within the quarter to the shock.

One important issue concerns where to order credit in the system. Goodhart and Hofmann (2008) order it last in their system. Since we incorporate equity prices in the analysis and it

weights on the coefficients for the foreign variables. This allows a more intuitive interpretation of the coefficients than the approach used here. We plan to estimate a GVAR model on our data in future work.

25 We follow Canova and Ciccarelli (2006) and construct all factors as the sum over the respective dimensions of the data.

seems likely that they respond more quickly to changes in the interest rate than credit aggregates, this does not seem appropriate in our case. Since it seems plausible that property prices respond to credit shocks, it seems desirable to order credit before both property and asset prices.

Finally, we have to decide whether to order credit before or after the interest rate. In the present draft we order it before the interest rate, under the argument that credit aggregates respond only gradually to changes in interest rates, but that underlying disturbances correlated with movements in the stock of credit can impact on interest rates within the quarter. In turn, this implies that the asset prices are ordered after the interest rate. We do not think that this assumption should be controversial since although central banks react to changes in asset prices (because they 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.

Before proceeding, two issues warrant discussion. First, we emphasise that these restrictions do not allow us to distinguish between aggregate supply and aggregate demand shock. Consequently, we will only discuss the effects of shocks to credit, interest rates and to the two asset prices below.

Second, while we attempt to give a structural interpretation to the shocks in our system, identification in such a large system is hazardous and we recognise that more work on the sensitivity of the results to the exact form of the identifying restrictions are needed. Indeed, Goodhart and Hofmann (2008) are careful not to interpret their orthogonalised shocks as structural. Though the same caveats apply to our analysis, we are willing to take somewhat greater risks. One reason for this is that since we do not include money in the system, we need not distinguish between money and credit shocks. Furthermore, using changes in, rather than the level of, property prices yields more plausible reactions to interest rate shocks which we feel more comfortable labelling monetary policy shocks.

4. Results

In this section we discuss the impulse-responses to monetary shocks, credit shocks, property-price and equity price shocks in the panel VAR before turning to the international transmission of these shocks in the next section. Figure 3 shows the bootstrapped impulse responses to a monetary policy shock implied by the panel regression, together with plus/minus two standard-error (i.e., 95%) confidence bands, obtained by bootstrapping (1000 draws).[26] The impulse responses are typically significantly different from zero at the 95% level because of the large amount of information that comes from using the panel approach.

After a monetary policy shock, the price level starts to fall, with the effect becoming significant only after about two years.[27] Furthermore, the results indicate that output falls for about seven quarters before recovering slowly. Credit starts to fall after about three quarters and reaches a trough about ten quarters after the shock. Residential property prices start to fall gradually and reach a trough after about ten quarters. Note that we plot impulse-responses for the level of property prices (i.e. accumulated impulse responses) to make results comparable to the other variables, though property prices enter the system in first differences. Since we assume that the level of property prices is non-stationary, they do not return to initial level. However, the effect is insignificant after four years. By contrast, equity prices, which are forward-looking variables, fall immediately following the increase in interest rates and start rising only after about seven quarters, that it, when real GDP starts to return to the initial level.

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, real GDP and credit show approximately the same pattern, whereas the price level is lagging and equity prices move more rapidly. Third, because we treat property prices as non-stationary, the width of the confidence bands increases with the time horizon and is larger than those for the other variables. Fourth, the point estimate shows that after about two years residential property

[26] When bootstrapping our PVAR, we sample from all residuals, not only from the residuals for a specific country. In that way, we account for the uncertainty that comes from the dispersion of the individual-country estimates around the mean-group parameters.

[27] It seems plausible that we underestimate the impact of monetary policy on prices since we do not include any predictors of future inflation in the VAR system.

prices and credit have fallen about three times as much as the level of real GDP, that is, by 1.8% rather than by 0.6%.

Of course, these estimates, in particular the three-to-one estimate, reflects 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 they would change if central banks actively sought to gear monetary policy to asset prices. With that caveat in mind, we interpret the results as suggesting 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 price booms, the central bank might have to depress real GDP by 5%, an extraordinarily large amount.[28] Moreover, the impact of monetary policy shocks on equity prices is much faster and larger than the peak effect on residential property prices, suggesting that monetary policy might not easily be used to target both. Overall, the results in this section are likely to fuel the fears of those that believe that gearing monetary policy to asset prices may generate pronounced swings in economic activity and will stabilise some asset prices at the costs of inducing more instability in others.

Figure 4 shows the impulse responses to a credit shock. In interpreting these it should be kept in mind that it is not clear a priori if this is a credit supply or credit demand shock. The estimates show that the shock raises the level of prices, with the peak effect being reached after twelve quarters. The shock also stimulates output, with a peak effect after about five quarters. The impact effect on interest rates is negative (suggesting that this is a credit supply shock).[29] Turning to the responses of asset prices, we note that after one quarter the shock is

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28 See also Assenmacher-Wesche and Gerlach (2008a). 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).

29 Recall that the interest rate is a three month rate whereas most central bank steer the overnight rate. Though the short-term interest rate is mainly determined by monetary policy, credit supply

associated with an increase of property prices, which is not significant, and an increase in nominal equity prices, which is.[30]

Next, we investigate the responses to a shock in the growth rate of property prices, which are shown in Figure 5. In contrast to the other shocks, this is a permanent shock to the level of property prices. Equity prices increase on impact. Interestingly, all other variables rise significantly in response to the shock. Again we have the same timing pattern among the variables. Equity prices peak after one quarter, real GDP, credit and the interest rate peak after three to four quarters, whereas the CPI lags with a peak after ten quarters.

Finally, Figure 6 shows the impulse responses to a shock in equity prices. Not surprisingly, the responses of the interest rate and property prices are small and insignificant. Real GDP and credit growth both expand, suggesting that innovations in equity prices do contain information about real growth in the near term. However, the effect is quantitatively small, with an equity price shock of about 10% leading to an increase in GDP of 0.3% after two quarters.

Figure 7 shows the variance decomposition of the variables in the system. Not surprisingly, the variances of the variables are predominantly due to "own" shocks. At a horizon of 6 years, interest rate shocks account for about 20% of the variation in the CPI and credit, and 28% of the fluctuations in GDP but only for 6% and 13% of the variation in property prices and equity prices. This again suggests that using monetary policy to stabilize asset prices risks destabilizing GDP. While asset prices to account for fluctuations in the interest rate and real credit, their contribution to variations in the CPI and GDP is quite limited.

Summing up, our system reproduces the usual findings for monetary policy shocks. In addition, we find that shocks to asset prices have a positive, significant effect on GDP and credit after three to four quarters, whereas the CPI starts to increase only after about two years. The results for the credit shock are somewhat more difficult to interpret. One reason

shocks should widen the spread between central-bank rates and money market rates and thus imply a rise in the interest rate.

[30] Note that since Goodhart and Hoffmann (2008) order credit last in their system, the impact reaction of property prices is constrained to be zero.

may be that the variables in our system to not allow us to separate demand and supply effects properly.

5. International transmission of shocks

Having identified the shocks and studied the average response of macroeconomic variables to them using the panel VAR, below we provide some evidence on how monetary policy, credit, property price and equity price shocks in the US are spread to the other countries in our panel. Using a multi-country VAR it becomes almost impossible to disentangle all structural shocks in the system. What can be done, however, is to identify shocks for a single country and then investigate the transmission to other economies. Since the US is the largest economy and has been a recent source of shocks, it seems natural to focus on shocks originating there.

To identify the shocks, we order the US first and then apply a Choleski decomposition to the residuals. Under the assumption that the US variables are exogenous to the system, we thus can identify structural shocks and study their transmission. We do not have to make any assumptions regarding the ordering of the remaining variables in the system since reordering them does not affect the results. We estimate the VAR with four lags. Since we are interested in the average effects of US shocks on the other economies, we present averages over the individual impulse responses.

Next we turn to the results. In interpreting them it should be noted that this exercise is quite different from that conducted above. While we previously implicitly shocked all the countries in the panel at the same time and studied how they responded on average, in this case we shock one country, the US, and study how the others respond, on average. It is therefore readily clear that we should not expect tightly estimated responses. Rather than using plus/minus two standard-errors wide confidence bands as above, we therefore use plus/minus one standard-error wide confidence bands in this part of the paper.

The responses to US monetary policy shocks are available in Figure 8. In the left-hand panel, the reaction to a monetary policy shock in the US is shown. Though the dynamics are somewhat different because the domestic variables are now regressed on the common factors, the reactions in the US are similar to those presented in the previous section and we therefore do not discuss them. The right-hand panel shows the average reaction in the other countries. On average in the current sample, an unexpected tightening of US monetary policy has been associated with a gradual increase in the level of prices abroad. This is compatible with the notion that the tightening leads to a depreciation of the currencies of the other countries. The tightening also leads to an immediate increase in interest rates abroad for about eight quarters and to a decline in the level of real GDP abroad, with the peak effect occurring after about three to four years. Given that real GDP declines, it is not surprising that credit, property prices and equity prices also do so, and at about the same rate.

Next we turn to responses to the other shocks. Before doing so, note that the shocks to prices and real GDP in the US – which are ordered first and second in the system, which we do not identify and therefore do not discuss – by construction have the opportunity to explain the greatest fraction of the variance of the other variables. Thus, while our results suggest limited responses by foreign variables to US shocks, it may be that the bulk of the comovements between US and foreign variables arise because of US aggregate supply and aggregate demand shocks which we do not discuss

Figure 9 shows the responses to credit shocks. We note that in the US the CPI increases only after several quarters, whereas real GDP is rises much more rapidly, though the effect is barely significant. In the other countries, real credit increases and the other variables are insignificant.

The response to a property price shock is shown in Figure 10. Interestingly, none of the reactions is significant, even with the relatively wide one-standard-error bounds. One reason for this may be that housing finance markets have been subject to large country-specific disturbances in the sample so that the common factors capture only small part of the variation in the VAR coefficients. Nevertheless, since we study responses to shocks only in the US, we are likely to underestimate the transmission of property price shocks in the current crisis since disturbances might also have been emanating from other economies with large real estate sectors, such as like the UK, Ireland or Spain.

Figure 11 shows the transmission of equity price shocks. Equity markets are highly linked across the world so that we would expect a strong transmission into other countries. Indeed, a shock to US equity prices leads to an almost identical increase in equity prices in the other economies. Interest rates fall with a peak effect in the US after 10 quarters, whereas the peak in the other countries is about two quarters later. While real credit and GDP increase in the US, there is no significant reaction abroad. In contrast to the PVAR results, the CPI falls.

6. Conclusions

In the first of this paper we have studied the joint behaviour of (the levels of) output, prices, credit, interest rates, equity prices and (changes in) property prices in a sample of 17 developed economies, using quarterly data spanning 1986 to 2006 and focussing the "average" behaviour across countries. In the second part, we have provided some preliminary evidence on the transmission of US shocks to the other countries.

In order to study the responses of shocks, we have attempted to identify credit, monetary policy, property price and equity price shocks by ordering the variables in this way and using a standard Choleski factorization (ordering prices and real GDP first and second in the system). While our specific identification scheme yields broadly plausible impulse responses, we nevertheless view them with some suspicion.

Several of the results warrant discussion. First, in the sample the effect of monetary policy shocks were roughly three times larger on real GDP than on property prices. While this estimate is sensitive to monetary policy regime in force during the sample and subject to the Lucas critique, taken at face value it suggests that the real output costs of seeking to stabilise property prices by "leaning against the wind" could be very large.

Second, property and equity prices respond at different speeds (but roughly to the same extent) to monetary policy shocks, suggesting that it might be difficult for policy makers to seek to stabilise both. However, we need again to be mindful of the fact that these estimates may change if policy makers' objectives for policy change.

Third, credit shocks are associated with statistically significant increases in the level of prices, real GDP and equity prices. By contrast, they do not seem to have a large impact on property prices. This suggests that the bulk of the variation in credit growth is related to expected future changes in real economic activity. The notion that fluctuations in credit growth have been a major driver of property price shocks seems not to be supported by the data.

Fourth, property price shocks appear to have important effects on all variables. While the effects on prices are protracted and peak after about four years, for the other variables they are much more short-lived, lasting at most two years. Since property prices are treated as I(2) variables in the analysis, such shocks have a permanent impact on property prices.

Fifth, equity price shocks seem only to impact on real GDP and credit. This finding is compatible with the notion that equity prices are largely driven by the near-term prospects of firms, which in turn drive the demand for credit.

Overall, these findings suggest that movements in credit are largely due to shifts in the demand, which in turn depends critical on the level of real economic activity.

Turning to the part of the paper in which we study the transmission of US shocks, we note that although US monetary policy shocks appears to elicit responses abroad, the other shocks do not. This finding seems difficult to reconcile with the spread of the subprime mortgage crises outside the US. It may be, however, that we underestimate this impact since our estimates captures the average effect during the 1986 to 2006 period when asset price shocks perhaps were not transmitted as strongly as after the end of the sample period. Whatever the reason, this issue warrants more work.

References

Ahearne, Alan G., John Ammer, Brian M. Doyle, Linda S. Kole and Robert F. Martin (2005), "House Prices and Monetary Policy: A Cross-Country Study," Board of Governors of the Federal Reserve System, International Finance Discussion Papers No. 841.

Angeloni, Ignazio, Anil K. Kashyap and Benoit Mojon (2003), Monetary Policy Transmission in the Euro Area, Cambridge University Press, Cambridge.

Arthur, Steven V. (2005), "Obtaining Real Estate Data: Criteria, Difficulties and Limitations," in: Bank for International Settlements (ed.), Real Estate Indicators and Financial Stability, Proceedings of a joint conference organised by the BIS and the IMF in Washington DC, 27-28 October 2003, BIS Papers No 21, Basel, 63-69.

Assenmacher-Wesche, Katrin and Stefan Gerlach (2008a), "Can Monetary Policy Really Be Used to Stabilize Asset Prices?," in: Andrew Felton and Carmen M. Reinhart (ed.), The First Global Financial Crisis of the 21st Century, Center for Economic Policy Research, London, 163-166.

Assenmacher-Wesche, Katrin and Stefan Gerlach (2008b), "Can Monetary Policy Be Used to Stabilise Asset Prices?," Institute for Monetary and Financial Stability Working Paper No. 16, University of Frankfurt.

Becker, Ralf, Urs Fischbacher and Thorsten Hens (2007), "Soft Landing of a Stock Market Bubble: An Experimental Study," National Centre of Competence in Research, NCCR Finrisk Working Paper No. 32.

Borio, Claudio and Philip Lowe (2002), "Asset Prices, Financial and Monetary Stability: Exploring the Nexus," BIS Working Paper No 114.

Cannari, Luigi, Ivan Faiella, Roberto Sabbatini and Francesco Zollino (2006), "House Prices in Italy: The Statistics Used at the Bank of Italy," Paper presented at the OECD-IMF Workshop on Real Estate Prices Indexes, Paris, 6-7 November 2006.

Canova, Fabio and Matteo Ciccarelli (2006), "Estimating Multi-Country VAR Models," European Central Bank Working Paper No. 603.

Cecchetti, Stephen G., Hans Genberg, John Lipsky and Sushil Wadhwani (2000), "Asset Prices and Central Bank Policy," Geneva Report on the World Economy 2, CEPR and ICMB.

Chow, Gregory C. and An-loh Lin (1971), "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series," Review of Economics and Statistics, 53, 372-375.

Christiano, Lawrence J., Martin Eichenbaum and Charles L. Evans (1999), "Monetary Policy Shocks: What Have We Learned and To What End?," in: John B. Taylor and Michael Woodford (ed.), Handbook of Macroeconomics, Elsevier, Amsterdam, 65-148.

Dees, Stephane, Filippo di Mauro, M. Hashem Pesaran and L. Vanessa Smith (2006), "Exploring the International Linkages of the Euro Area: A Global VAR Analysis," Journal of Applied Econometrics, 22, 1-38.

Economist (2008), "Building Wealth - Japan's Property Markets," January 3rd, 2008.

Eitrheim, Oyvind and Solveig K. Erlandsen (2004), "Chapter 9 - House Price Indices for Norway 1819-2003," in: Oyvind Eitrheim, Jan T. Klovland and Jan F. Qvigstad (eds), Historical Monetary Statistics for Norway, Norges Bank, Oslo, 349-375.

Gerardi, Kristopher, Andreas Lehnert, Shane Sherlund and Paul Willen (2008), "Making Sense of the Subprime Crisis," Brookings Papers on Economic Activity, Fall,

Gerlach, Stefan and Wensheng Peng (2005), "Bank Lending and Property Prices in Hong Kong," Journal of Banking and Finance, 29, 461-481.

Girouard, Natalie and Sveinbjörn Blöndal (2001), "House Prices and Economic Activity," OECD Economic Department Working Paper 279.

Goodhart, Charles A.E. and Boris Hofmann (2007), House Prices and the Macroeconomy: Implications for Banking and Price Stability, Oxford University Press, Oxford.

Goodhart, Charles A.E. and Boris Hofmann (2008), "House Prices, Money, Credit, and the Macroeconomy," Oxford Review of Economic Policy, 24, 180-205.

Hofmann, Boris (2003), "Bank Lending and Property Prices: Some International Evidence," HKIMR Working Paper No. 22.

Holtz-Eakin, Douglas, Whitney Newey and Harvey S. Rosen (1988), "Estimating Vector Autoregressions with Panel Data," Econometrica, 56, 1371-1395.

Hunter, William C., George G. Kaufman and Michael Pomerleano (2003), Asset Price Bubbles: The Implications for Monetary, Regulatory, and International Policies, MIT Press, Cambridge, MA.

Im, Kyung So, M. Hashem Pesaran and Yongcheol Shin (2003), "Testing for Unit Roots in Heterogenous Panels," Journal of Econometrics, 115, 53-74.

International Monetary Fund (2008), "The Changing Housing Cycle and the Implications for Monetary Policy," World Economic Outlook, 2008, 103-132.

Kohn, Donald L. (2006), "Monetary policy and asset prices," Speech at "Monetary Policy: A Journey from Theory to Practice," a European Central Bank Colloquium held in honor of Otmar Issing, Frankfurt, March 16, available at www.federalreserve.gov/newsevents/speech/kohn20060316a.htm.

Lastrapes, William D. (1998), "International Evidence on Equity Prices, Interest Rates and Money," Journal of International Money and Finance, 17, 377-406.

Levin, Andrew, Chien-Fu Lin and Chia-Shang James Chu (2002), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Journal of Econometrics, 108, 1-24.

Pedroni, Peter (1999), "Critical Values for Cointegration Tests in Heterogenous Panels with Multiple Regressors," Oxford Bulletin of Economics and Statistics, Special Issue, 653-670.

Pesaran, M. Hashem, Til Schuermann and Scott Weiner (2004), "Modelling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model," Journal of Business and Economic Statistics, 22, 129-162.

Pesaran, M. Hashem and Ron Smith (1995), "Estimating Long-Run Relationships from Dynamic Heterogeneous Panels," Journal of Econometrics, 68, 79-113.

Sims, Christopher A. and Tao A. Zha (1999), "Error Bands for Impulse Responses," Econometrica, 67, 1113-1156.

Tsatsaronis, Kostas and Haibin Zhu (2004), "What Drives Housing Price Dynamics: Cross-Country Evidence," BIS Quarterly Review, March 2004, 65-78.

Table 1. Detailed unit-root test results.

Levels	CPI	GDP	Credit	Interest rate	Prop. price	Equity price
Australia	-3.02	-1.35	-2.36	-2.28	-2.58	-1.48
Belgium	-2.97	**-4.10**	-3.12	-1.01	-0.56	-2.63
Canada	-3.10	-2.28	**-5.03**	-1.20	-1.22	-2.04
Denmark	-3.17	-2.76	-1.03	-1.35	-1.69	-2.96
Finland	-3.01	-2.15	-2.19	-1.24	-1.56	-1.90
France	-1.93	-2.49	**-3.67**	-0.94	-2.97	-3.37
Germany	-1.09	-2.55	0.20	-2.18	-0.76	-2.26
Ireland	-1.72	-2.23	-1.25	-2.62	-1.77	-2.00
Italy	-1.55	-2.76	**-3.86**	-0.81	-2.53	-2.25
Japan	-1.27	-3.02	-3.19	-1.34	-4.80	-2.71
Netherlands	-2.17	-2.58	-1.63	-0.79	-2.02	-1.93
Norway	-2.53	-2.17	-2.02	-1.50	-3.13	-1.77
Spain	-1.87	-2.50	0.40	-0.71	-3.12	-1.97
Sweden	-2.29	-1.25	-2.21	-0.77	-2.15	-1.67
Switzerland	-3.31	-1.38	-2.68	-1.36	-2.63	-1.97
UK	-2.26	-2.49	**-3.73**	-1.30	-0.56	-1.96
US	-2.46	-1.67	-0.20	-2.21	-1.16	-2.03
1st diff.						
Australia	**-3.00**	**-7.30**	**-3.92**	-2.81	-2.32	-2.78
Belgium	**-3.63**	**-4.98**	-2.05	**-7.86**	**-3.14**	-2.52
Canada	**-5.60**	**-3.23**	-2.60	**-7.25**	-2.20	**-3.95**
Denmark	**-2.92**	-2.32	-2.53	**-9.39**	-2.17	**-4.93**
Finland	-1.77	-2.44	-1.74	**-4.37**	**-3.02**	**-3.36**
France	-2.26	**-2.95**	-2.38	**-8.83**	-1.73	-2.61
Germany	**-3.04**	**-3.04**	-0.24	**-2.92**	**-3.13**	**-3.37**
Ireland	**-3.58**	-2.74	**-3.18**	**-9.47**	-2.29	**-3.06**
Italy	-0.83	**-3.62**	-1.96	**-5.17**	-1.52	**-4.07**
Japan	-2.78	**-2.96**	-2.02	**-3.93**	-1.15	**-4.80**
Netherlands	**-3.61**	-2.69	**-6.88**	**-5.35**	-2.38	-2.06
Norway	**-4.09**	**-9.53**	-2.73	**-6.93**	-2.62	**-7.12**
Spain	-1.69	-2.28	-1.61	**-3.92**	-1.71	-2.37
Sweden	-2.02	**-9.86**	-2.20	**-3.43**	-2.23	**-6.79**
Switzerland	-1.64	**-6.78**	-2.23	**-2.33**	-1.81	-2.35
UK	-1.70	**-3.12**	**-2.97**	**-3.52**	-2.33	-2.55
US	-1.95	**-3.92**	**-5.67**	**-3.33**	-1.95	-2.32

Except for the interest rate, where we include a constant only, the tests for the levels include a constant and a trend and five lags, whereas the test for the differences include a constant and four lags. The test statistics are distributed as N(0,1). Bold face denotes significance at the 5 percent level.

Figure 1. Log residential property prices (solid) and log credit (dashed)

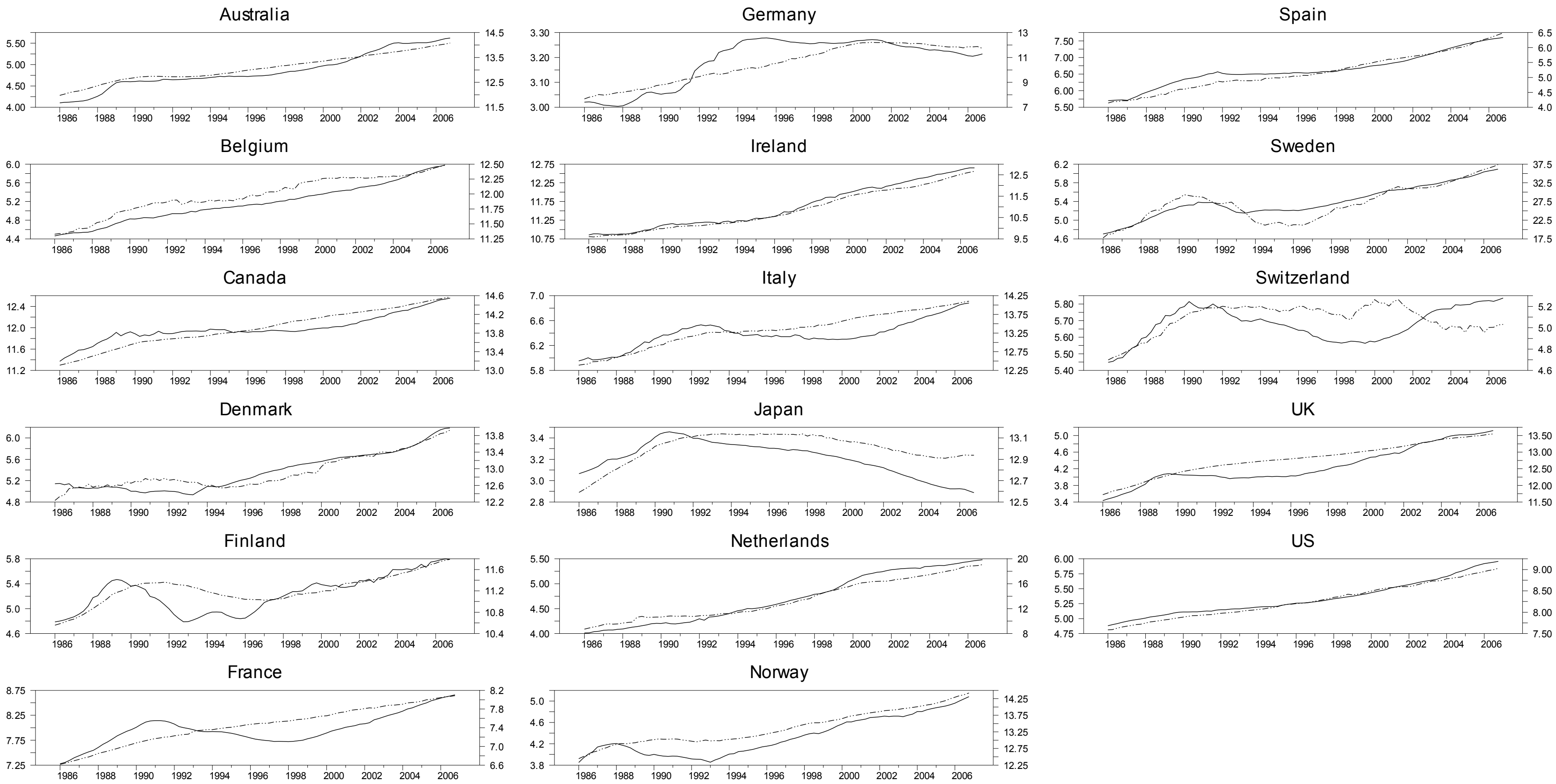


Figure 2. Log residential property prices in levels (solid) and first differences (dashed)

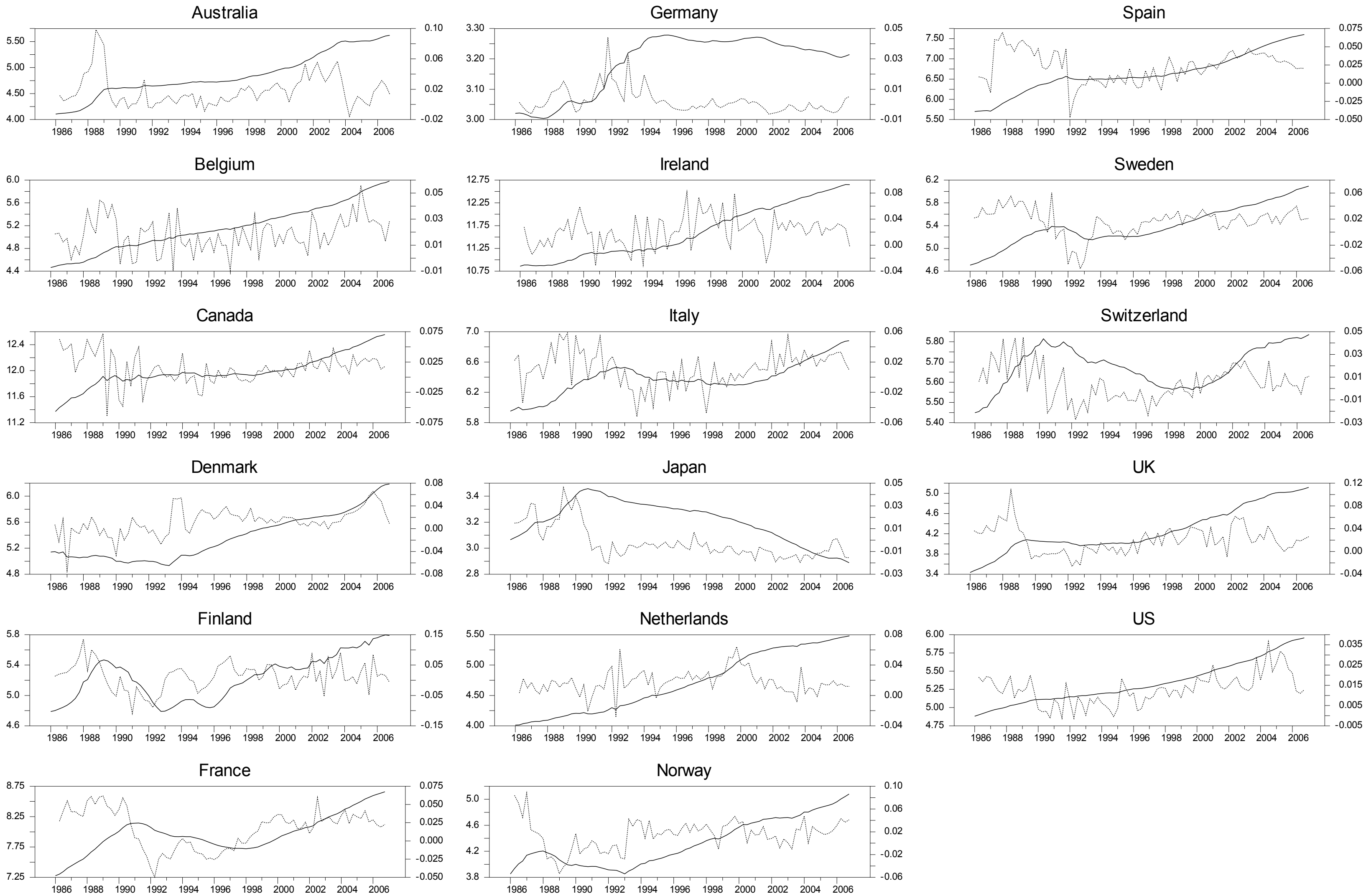
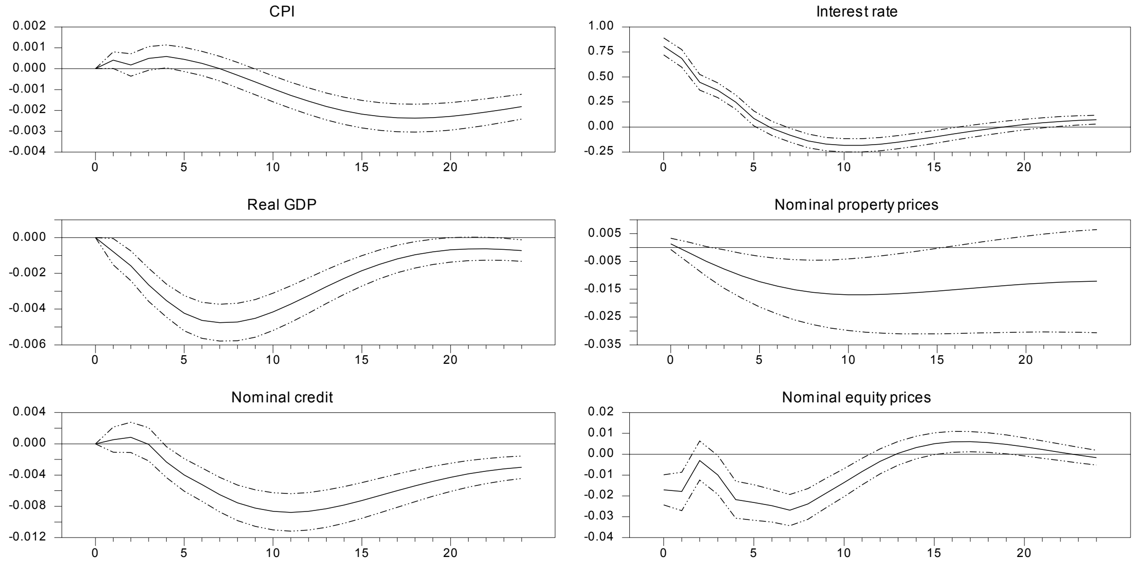
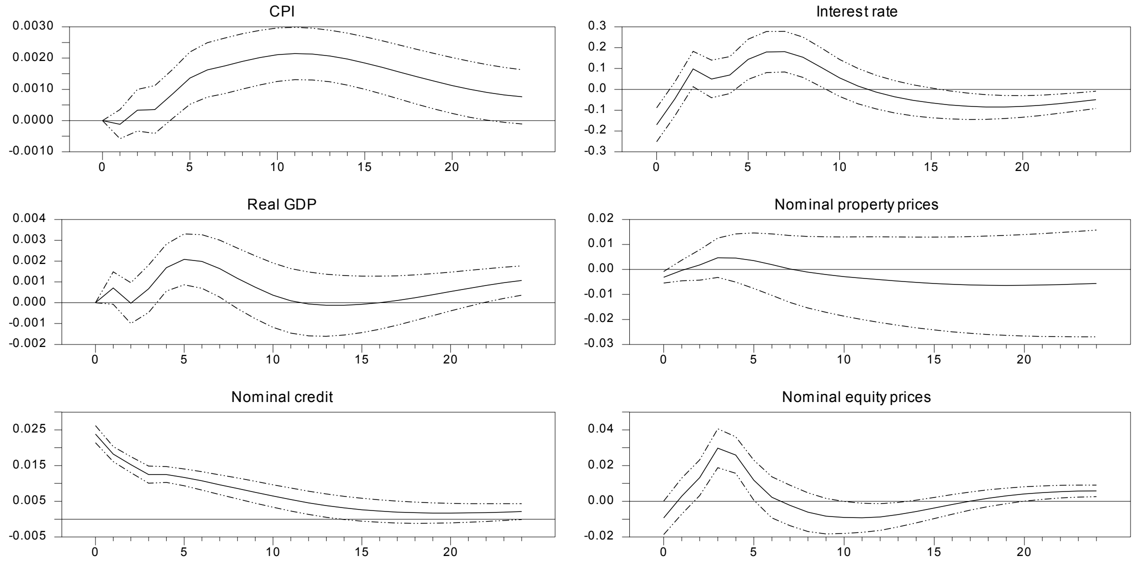


Figure 3. Impulse responses to a monetary policy shock



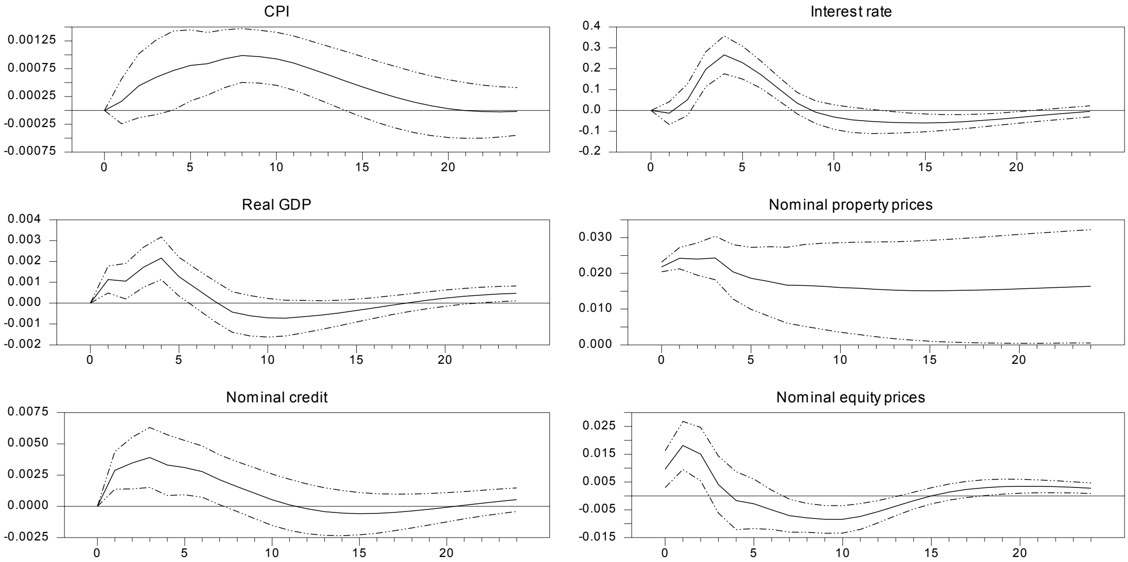
Note: Impulse responses are the bootstrapped mean response, using the approach recommended by Sims and Zha (1999). The dashed lines indicate two-standard-error confidence bands. Results are based on 1000 bootstrap replications.

Figure 4. Impulse responses to a credit shock



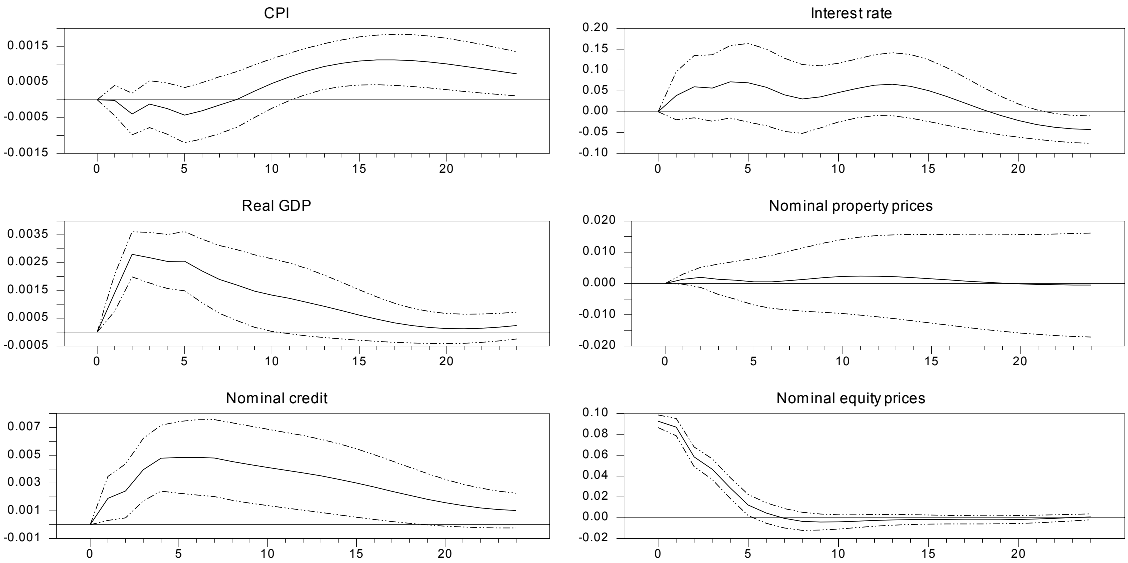
Note: See note to Figure 3.

Figure 5. Impulse responses to a property-price shock



Note: See note to Figure 3.

Figure 6. Impulse responses to an equity-price shock



Note: See note to Figure 3.

Figure 7. Variance decomposition

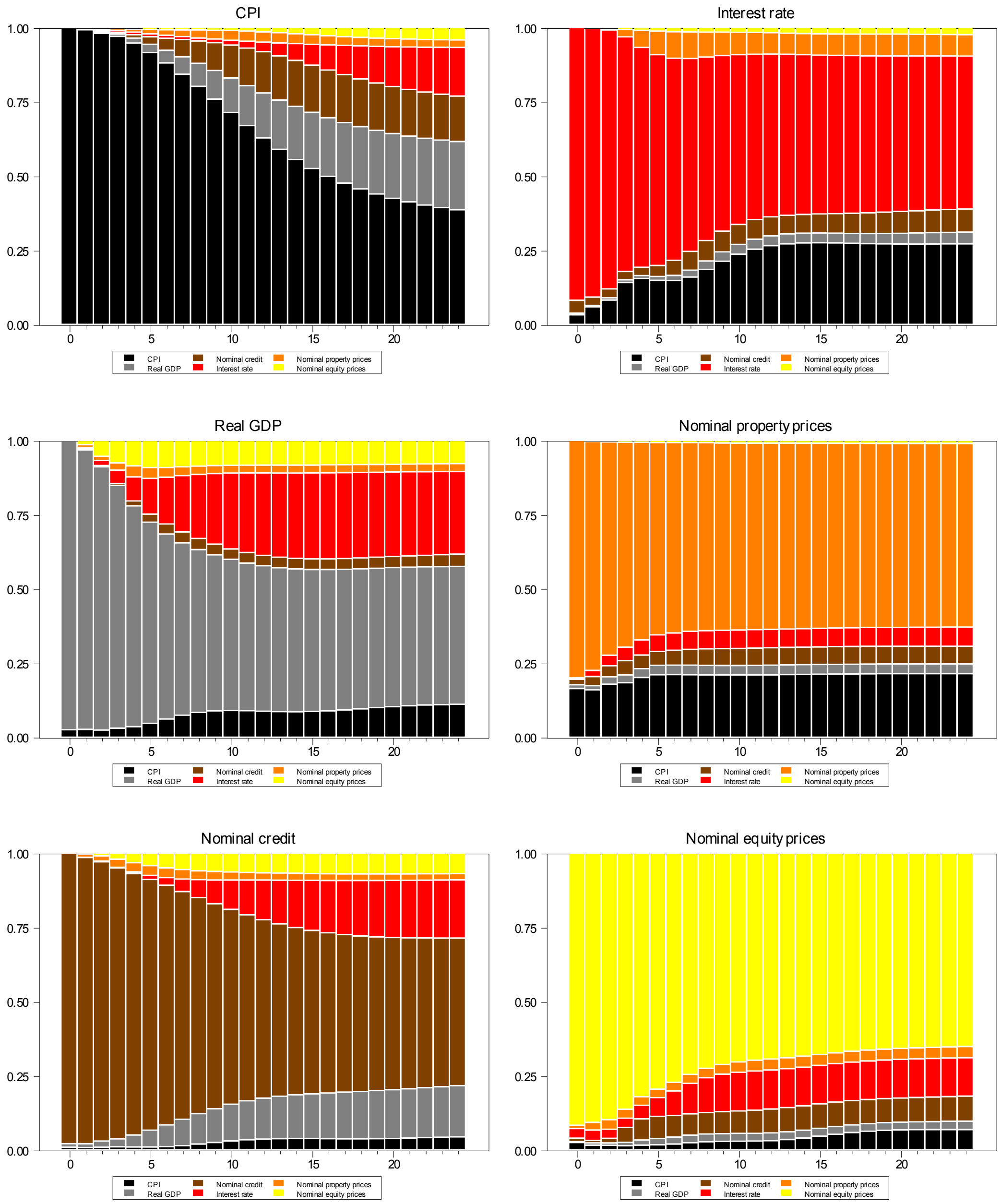
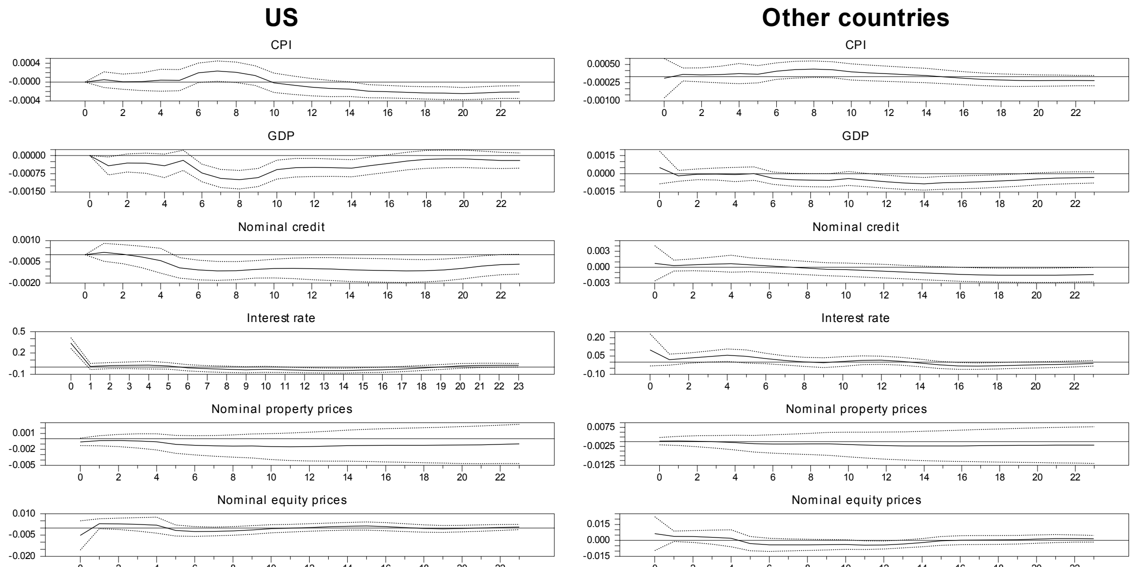
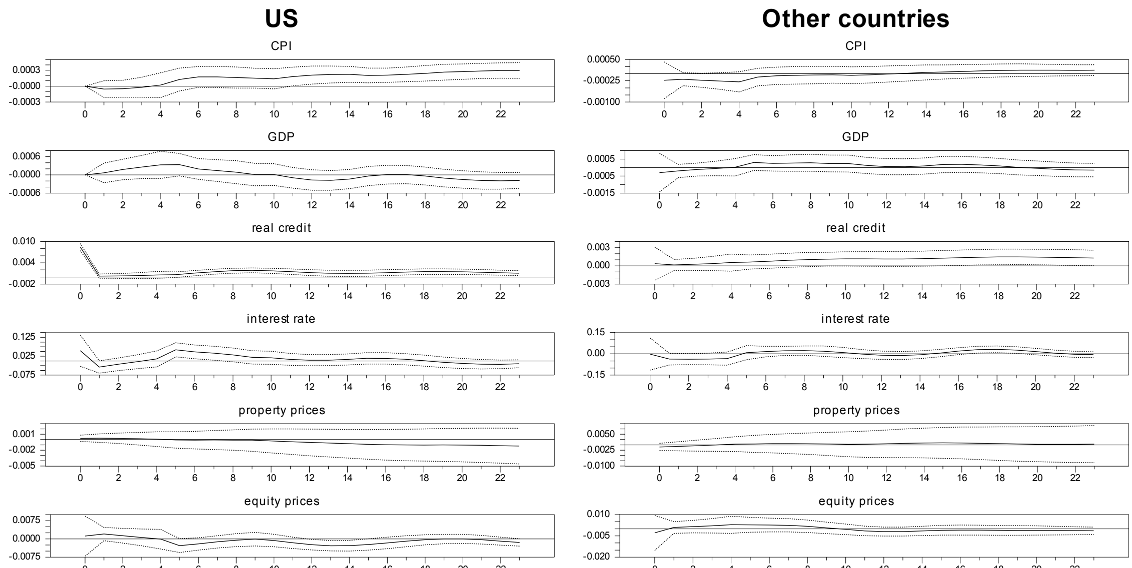


Figure 8. International transmission of a US monetary policy shock



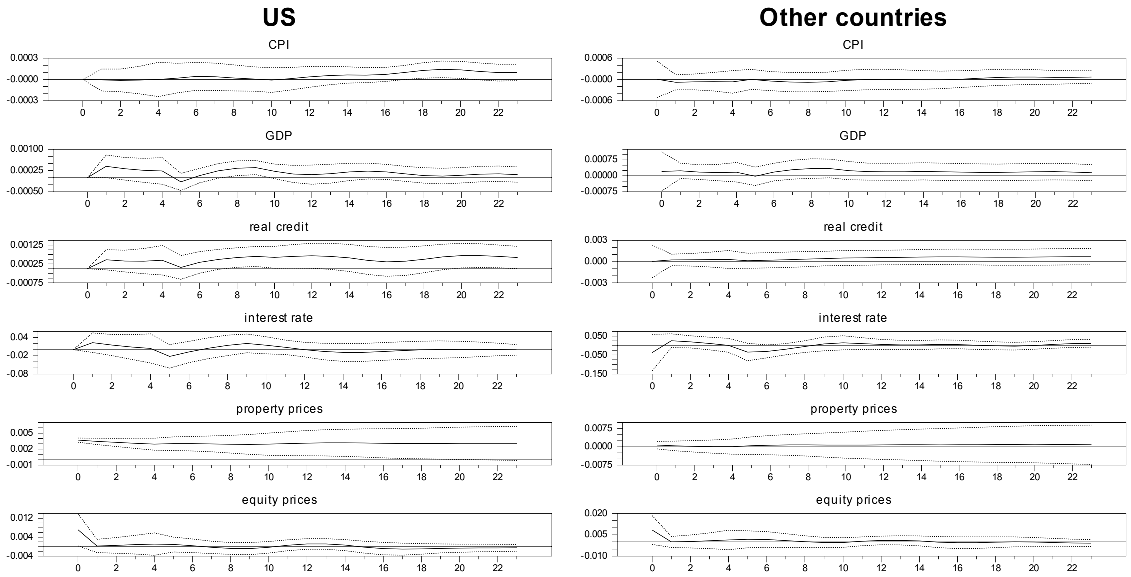
Note: Impulse responses are the bootstrapped mean response, using the approach recommended by Sims and Zha (1999). The dashed lines indicate one-standard-error confidence bands. Results are based on 200 bootstrap replications.

Figure 9. International transmission of a US credit shock



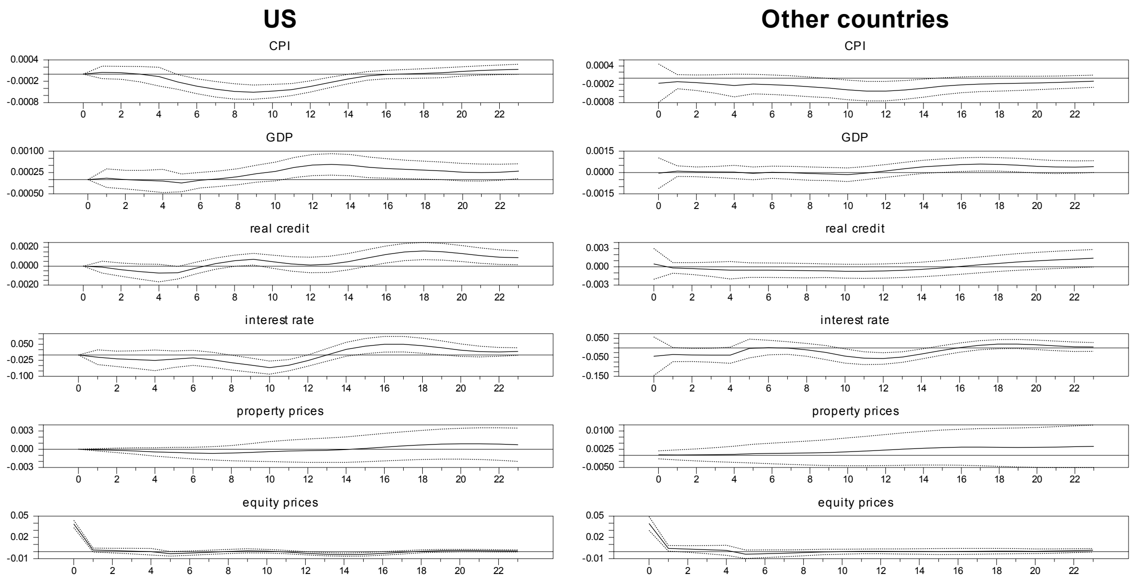
Note: See note to Figure 8.

Figure 10. International transmission of a US property price shock



Note: See note to Figure 8.

Figure 11. International transmission of a US equity price shock



Note: See note to Figure 8.