FINESS
SEVENTH FRAMEWORK PROGRAMME
Project funded under the Socio-economic Sciences and Humanities

Working Paper D.7.4

European Commission

Monetary Policy Transmission and House Prices: European Cross Country Evidence

Kai Carstensen, Oliver Hülsewig and Timo Wollmershäuser

February 2009

Monetary Policy Transmission and House Prices: European Cross Country Evidence*

Kai Carstensen† Oliver Hülsewig‡ Timo Wollmershäuser§

February 15, 2009

Abstract

This paper explores the importance of housing and mortgage market heterogeneity in 13 European countries for the transmission of monetary policy. We use a pooled VAR model which is estimated over the period 1995–2006 to generate impulse responses of key macroeconomic variables to a monetary policy shock. We split our sample of countries into two disjoint groups according to the impact of the monetary policy shock on real house prices. Our results suggest that in countries with a more pronounced reaction of real house prices the propagation of monetary policy shocks to macroeconomic variables is amplified.

JEL classifications: C32, C33, E52

Key words: Pooled VAR model, house prices, monetary policy transmission, country clusters, sign restrictions.

*We thank Johannes Mayr and Steffen Elstner for kindly helping us with collecting the data. The usual disclaimer applies. The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement number 217266.

†LMU and Ifo Institute for Economic Research. *Email:* `<Carstensen@ifo.de>`

‡Corresponding author. Ifo Institute for Economic Research, Poschingerstr. 5, 81679 München, Germany. Tel: +49(0)89 9224–1689. Fax: +49(0)89 9224–1462. *Email:* `<Huelsewig@ifo.de>`

§CESifo and Ifo Institute for Economic Research. *Email:* `<Wollmershaeuser@ifo.de>`

1 Introduction

Modern central banks are typically responsible for the maintenance of price stability. The pursuit of price stability requires an understanding of the transmission process of monetary policy, which comprises a variety of transmission channels that characterize the effects of monetary policy on output and inflation. Mishkin (2007) and Muellbauer and Murphy (2008) have highlighted those transmission channels that assign the housing market an important role in the propagation of monetary policy shocks.

In industrial countries, the importance of housing for the transmission of monetary policy stems from the link between the development of key macroeconomic variables and fluctuations in house prices (Mishkin, 2007). House prices are affected by a number of factors including income, the housing stock, credit availability and ultimately changes in interest rates induced by monetary policy (Muellbauer and Murphy, 2008). House price fluctuations have an impact on consumption decisions of households – via housing wealth and housing collateral effects – and residential investment – e.g. via Tobin's q by affecting the value of housing relative to construction costs (Goodhart and Hofmann, 2008). The importance of housing is related to the institutional characteristics of mortgage markets, which determine the availability of housing credit and the speed of adjustment of mortgage rates to changing money market rates. Since mortgage markets have been deregulated continuously over the past years (IMF, 2008), this suggests that the significance of housing for the propagation of monetary policy has increased.

Some of these considerations have recently been included in Dynamic Stochastic General Equilibrium (DSGE) models. Papers by Iacoviello (2005), Iacoviello and Neri (2007), Monacelli (2009), and Pariès and Notarpietro (2008) have shown a particular interest in understanding the role played by credit market frictions faced by households, focussing on the influence of housing collateral on households' consumption decisions.[1] The main result of this literature is that

[1]Typically, these models distinguish between two types of households: Patient households (with a high discount factor) lend money to impatient households, which face collateral requirements when asking for loans. Moreover, there are two types of firms: non-durable con-

the presence of credit frictions (i.e., collateral constraints) amplifies the propagation of monetary policy shocks to the macroeconomy.

This paper empirically explores the role of housing markets in European countries for the transmission of monetary policy. We use a pooled vector autoregressive (VAR) model to generate impulse responses of key macroeconomic variables to a monetary policy shock taking special account of the reaction of real house prices. As suggested by Canova and de Nicolo (2002), Peersman (2005) and Uhlig (2005) the monetary policy shock is identified using the sign restrictions approach. The main reason for pooling our sample of 13 countries is the short time period of the data, ranging from 1995 Q1 to 2006 Q1. We select this period since the process of deregulation of mortgage markets has been accomplished mostly until the mid–1990s (Girouard and Blöndal, 2001), even though certain restrictions still exist. Moreover, the disinflationary process had been completed in most European countries in the mid–1990s and monetary regimes had become very similar across countries, both of which is essential when it comes to evaluating the effects of a monetary policy shock in a cross–country study.

So far, a number of papers have employed VAR models for European countries to explore the reaction of house prices to a monetary policy shock. Iacoviello (2002), Iacoviello and Minetti (2003), Giuliodori (2005), IMF (2008) and Calza, Monacelli, and Stracca (2006) find that house prices across countries respond differently to changes in interest rates. The differences in the reaction of house prices can be related to country–specific characteristics of national mortgage markets. Specifically, several institutional indicators such as the typical duration of mortgage contracts, the loan–to–value (LTV) ratio, the existence of equity release products and the terms of adjustment of mortgage rates vary across countries. Countries where mortgage markets are more developed experience a higher volatility of house prices and a greater role for housing in the transmission of monetary policy.

Although the development of mortgage markets across countries is likely a

sumption goods producers and residential (durable) goods producers. The latter can either be directly consumed (thereby providing utility), or can be used as collateral in the credit market to obtain extra funds for financing consumption.

source of cross–country heterogeneity, a quantitative comparison of the effects is difficult to establish because the estimates reported are often imprecise due to low degrees of freedom. Thus, Goodhart and Hofmann (2008) suggest using a panel VAR model to increase the power and the efficiency of the analysis. They assess the link between real output, monetary variables and house prices for a panel of 17 OECD countries over the period from 1973 to 2006. They find a significant relationship between these variables, which has become stronger in the period from 1985 to 2006 after mortgage markets have been liberalized substantially.

Assenmacher-Wesche and Gerlach (2008) also estimate a panel VAR model for the same set of OECD countries over the period from 1986 to 2006. They split their sample of countries into different groups to assess the role of institutional characteristics of mortgage markets for the transmission of monetary policy. The sub–panels are exogenously determined by using a broad range of indicators that reflect cross–country differences in the structure of mortgage financing. They conclude that institutional characteristics of mortgage markets across countries shape the response of house prices to monetary policy shocks, but the differences between the groups are quantitatively unessential.

Overall, the evidence suggests that housing in European countries plays a certain role in the transmission of monetary policy, but it is difficult to identify the cross–country differences precisely. The development of mortgage markets is likely a source of heterogeneity, however the separation of countries by means of institutional indicators is cumbersome since (i) a general agreement on which of the indicators are most important is missing, (ii) the classification of the indicators is often arbitrary, and (iii) indicators for a particular country often point in the opposite direction concerning their role for the transmission of monetary impulses.

To detect heterogeneities in the transmission of a structural shock in the context of a pooled VAR model we suggest a data–driven approach that clusters countries into disjoint groups according to the impact of the monetary policy shock on real house prices. We split our sample of countries into two groups – a *strong reaction group* and a *weak reaction group* – that are endogenously identified by using a distance measure, which is determined by the absolute value of the difference between cumulated impulse responses of real house prices. We compare the impulse responses of the two groups of countries to assess the effects of movements in real house prices after a change in the policy rate.

Our results show that macroeconomic variables in European countries co–move with real house prices after a monetary policy shock, but there are significant cross–country differences. The distinction of countries according to their house price response shows that the impact of monetary policy on real GDP (and in particular private consumption) and the overall price level in the *strong reaction group* is more pronounced. In addition, we find that the development of mortgage markets across countries is capable to explain the divergences in the volatility of house prices after a change in interest rates, but other cross–country features such as national traditions, cultural factors, the share of the housing sector in overall economic activity, the number of employees in the construction sector, regulations regarding housing taxes and housing subsidies or transaction costs are also likely relevant. We derive this conclusion by recognizing that our grouping of countries is not strictly related to the institutional indicators that are deemed essential.

Overall, our results suggest that heterogeneity of housing and mortgage markets across countries reflects differences in the transmission of monetary policy, which can be explained by the amplifying effects that arise from movements in real house prices after a monetary policy shock. Since the discrepancies are sizable, we conclude that monetary policy should be concerned about the influence of house prices when setting interest rates.

The remainder of the paper is organized as follows. In Section 2, the baseline pooled VAR model for our sample of countries is presented. We generate impulse responses to a monetary policy shock to explore the reaction of real house prices to an innovation in interest rates. Section 3 sets out our approach of identifying disjoint groups of countries. We discuss the institutional characteristics of mortgage markets across countries, describe our methodology and comment our findings. In Section 4, we compare impulse responses of the groups of countries to a monetary policy shock to assess the influence of movements in real house prices. Section 5 provides concluding remarks.

2 Benchmark VAR Model

Consider a pooled VAR model in reduced form:

$$X_t = c + \sum_{j=1}^{p} A_j X_{t-j} + \varepsilon_t, \tag{1}$$

where X_t is a matrix of endogenous variables, c is a matrix of country specific constant terms, A is a matrix of autoregressive coefficients, p is the number of lags and ε_t is a matrix of error terms. The matrix X_t consists of four columns:

$$X_t = \left[y_t \quad p_t \quad s_t \quad hp_t\right], \tag{2}$$

where (y_t) denotes real GDP, (p_t) is the overall price level, measured by the GDP deflator, (s_t) is the nominal short–term interest rate, which serves as the policy instrument of the central banks and (hp_t) are real house prices – i.e. nominal house prices deflated with the GDP deflator. Each column is a stacked vector of country variables, consisting of $M \cdot T$ rows, where M denotes the number of countries and T is the number of observations corrected for the number of lags p.

The VAR model is estimated via Bayesian methods using quarterly data for 13 European countries taken from the OECD over the period from 1995Q1 to 2006Q4.[2] Our sample of countries comprises Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. All variables are in logs – except for the nominal short–term interest rate, which is expressed in percent – and linearly de–trended. The matrix of constant terms c comprises individual country dummies that account for possible heterogeneity across the units. We use a lag order of $p = 3$, which ensures that the residuals are free of first–order serial correlation.[3]

Based on the VAR model (1) we generate impulse responses of the variables to a monetary policy shock. As in Canova and de Nicolo (2002), Peersman

[2]Appendix A provides a detailed description of the data. Since mortgage markets in European countries experienced an extensive phase of liberalization (IMF, 2008), which started in the early 1980s and ended in the mid 1990s (Girouard and Blöndal, 2001), we decided to focus on the period after the process of deregulation has been accomplished.

[3]See Appendix B for the results of tests for first–order autocorrelation.

(2005) and Uhlig (2005) we identify the shock by imposing sign restrictions that incorporate the notion that a contractionary monetary policy shock has a non–positive impact on real output (y_t), the overall price level (p_t) and real house prices (hp_t) as well as a non–negative impact on the short–term interest rate (s_t). While the restrictions imposed on real output, the price level and the short–term interest rate are standard (Peersman, 2005), the restriction imposed on real house prices follows from theoretical considerations derived from DSGE models which incorporate a housing sector and which show that real house prices should decline on impact after a monetary contraction rather than rise.[4] For all variables the time period over which the sign restrictions are binding is set equal to two quarters. The restrictions are imposed as $\leq$ or $\geq$.

The advantage of sign restrictions over Cholesky or Blanchard–Quah decompositions is that we do not have to impose zero restrictions on the contemporaneous or long–run impact of shocks. Short-run restrictions are typically inconsistent with a large class of general equilibrium models (Canova and Pina, 2005), and long-run restrictions may be substantially biased in small samples (Faust and Leeper, 1997). The sign restrictions approach only makes explicit use of restrictions that we often use implicitly. Having a certain theoretical understanding in mind, we typically experiment with the model specification until the impulse responses look reasonable (Peersman, 2005). This a priori theorizing is made more explicit with sign restrictions.

2.1 Basic Estimation Results

Figure 1 shows the impulse responses of the variables to a contractionary monetary policy shock, which is normalized to unity, i.e. 100 basis points.[5] The solid lines display the median of the impulse responses and the shaded areas are the 68% confidence intervals. As the median and the quantiles were computed from

[4]See for example the papers by Iacoviello (2005), Iacoviello and Neri (2007), Monacelli (2009), and Pariès and Notarpietro (2008)

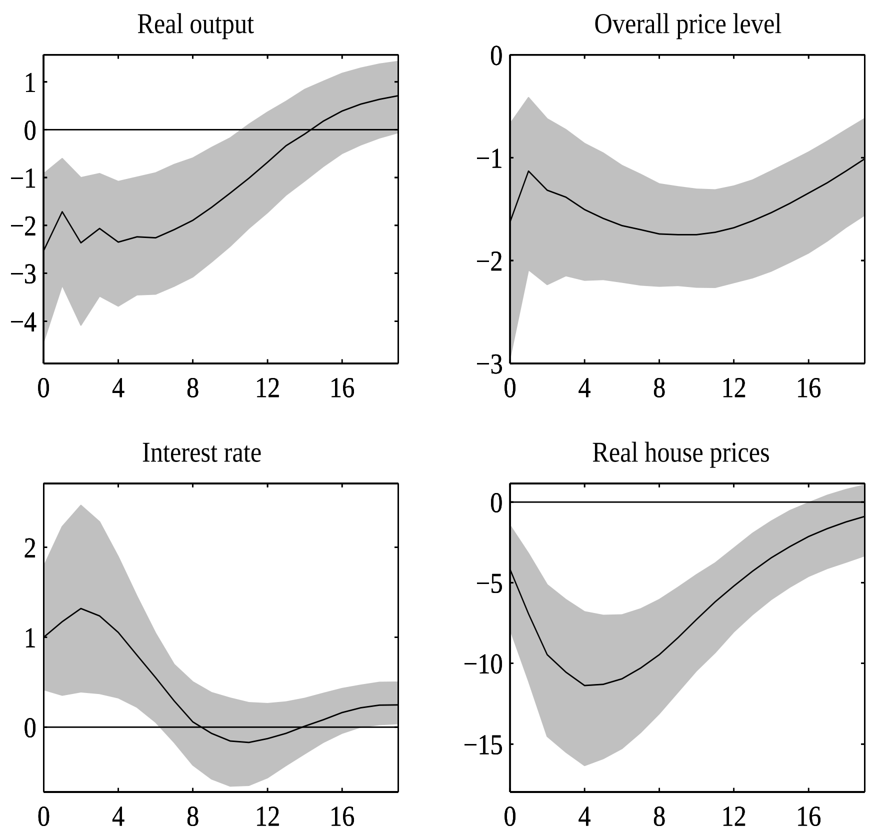
[5]The Bayesian estimation and the identification of the monetary policy shock using sign restrictions were performed with Fabio Canova's MATLAB codes `bvar.m`, `bvar_chol_impulse.m` and `bvar_sign_ident.m`, which can be downloaded from his website (http://www.crei.cat/people/canova/).

all impulse responses that satisfy the sign restrictions, the confidence intervals not only reflect sampling uncertainty, but also modeling uncertainty stemming from the non–uniqueness of the identified monetary policy shock. The simulation horizon, which is depicted on the horizontal axis, covers 20 quarters. The responses of real output, the overall price level and real house prices are expressed in percent terms, while the response of the interest rate is expressed in units of percentage points at an annual rate. Notice that the immediate responses of all variables are constrained after the impact so that little interpretation needs to be given to the sign of the adjustment for the first two quarters.

Real output falls after the monetary policy shock and remains below the baseline value for around 16 quarters. The decline in the overall price level is very persistent. The short–term interest rate remains above baseline for around 10 quarters and reverts to it afterwards. Real house prices display a hump–shaped response – which is consistent with the findings of e.g. Assenmacher-Wesche and Gerlach (2008), Iacoviello and Minetti (2003) and Calza, Monacelli, and Stracca (2006) – and return gradually to the baseline value after around 20 quarters. Considering the responses of the overall price level and real house prices two remarks are in order. First, nominal house prices – calculated as real house prices plus the overall price level – decline in reaction to a contractionary monetary policy shock. Second, the adjustment of nominal house prices is more flexible than the adjustment of the overall price level over the simulation horizon, which means that nominal house prices are less sticky.

The forecast error variance decomposition presented in Table 1 provides some additional information on the quantitative impact of the monetary policy shock. Regarding the volatility of real output the monetary policy shock explains a share of around 18% over the simulation horizon (corresponding to the median impulse response function). Movements in the overall price level are accounted for by the monetary policy shock in a sizable fraction, starting with 13% immediately after the occurrence of the shock and continuously increasing up to 39%. Moreover, regarding the volatility of real house prices the monetary policy shock explains a share of 12% on impact of the shock, with a continuous increase to 34% at the end of the simulation horizon. We interpret this figure as a remarkable fraction, given that real house prices should be also affected by

Figure 1: Baseline VAR Model: Impulse Responses to a Monetary Policy Shock



Notes: The solid lines denote the median of the impulse responses, which are identified from a Bayesian vector–autoregression with 1000 draws using sign restrictions; the shaded areas are the related 68% confidence intervals. Real output, the overall price level and real house prices are expressed in percent terms, while the interest rate is expressed in units of percentage points at an annual rate.

Table 1: Forecast Error Variance due to a Monetary Policy Shock

Horizon	Real output	Overall price level	Interest rate	Real house prices
1	16.03	12.85	12.69	11.99
2	15.63	12.37	10.62	17.21
3	15.90	13.18	10.43	21.47
4	16.53	14.30	10.65	23.66
6	18.51	17.71	10.83	27.62
8	19.51	22.16	11.33	30.41
10	20.29	27.08	11.37	33.27
12	19.66	31.46	11.70	34.18
14	18.99	35.09	11.83	34.34
16	18.55	37.22	11.84	34.47
18	18.44	38.34	12.02	34.88
20	18.87	39.19	12.19	34.45

Notes: For all variables in the pooled VAR model the figures display the percent of the variance in the reduced form innovation at different horizons attributable to a monetary policy shock.

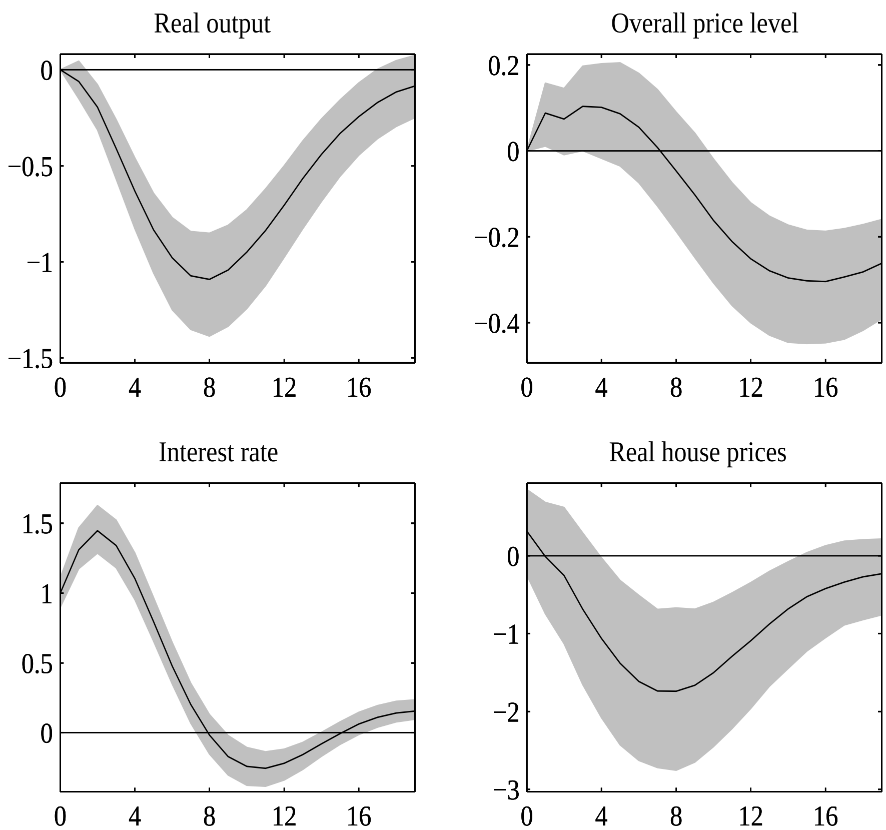
real output and price level innovations.

2.2 Alternative Identification Scheme

We check the robustness of our results by generating impulse responses of the variables to a monetary policy shock, which is identified by imposing a triangular (Cholesky) decomposition of the variance–covariance matrix of the reduced–form shocks (Sims, 1980). The ordering of variables in the matrix X_t implies that real output and the overall price level are hit by an innovation in the nominal short–term interest rate with a lag of one quarter, while real house prices are affected contemporaneously. The impulse responses of the variables are shown in Figure 2 together with the corresponding error bounds.

The findings show that real output falls after a monetary policy shock, exhibiting a humped–shaped response, and returns to the baseline value subsequently. Prices initially increase for about 8 quarters before they start to fall. The initial rise of prices reflects the presence of a *price puzzle* (Sims, 1992), which is also reported in related studies – see e.g. Goodhart and Hofmann (2008) –

Figure 2: Alternative Identification Scheme



Notes: The solid lines denote the median of the impulse responses, which are identified from a Bayesian vector–autoregression with 1000 draws using a triangular decomposition of the variance–covariance matrix of the reduced–form shocks; the shaded areas are the related 68% confidence intervals. Real output, the overall price level and real house prices are expressed in percent terms, while the interest rate is expressed in units of percentage points at an annual rate.

that impose zero restrictions on the contemporaneous impact of the shock.[6] Real house prices slightly increase on impact after a monetary policy shock, but the rise is statistically insignificant. They decline afterwards, reaching their trough after around 7 quarters, and return to the baseline value subsequently.

While the identification strategy seems to be irrelevant for the response of the short–term nominal interest rate, a comparison of the remaining impulse responses with those resulting from the sign restriction approach yields some important differences. Using the triangular decomposition the effects of a monetary policy shock are less pronounced and more delayed (see Peersman, 2005, for similar results). Under sign restrictions an unexpected 100 basis point increase in the policy instrument depresses real output instantaneously by around 2%, whereas the triangular decomposition leads to a decline in real output by a bit more than 1% after two years. The maximum impact on the overall price level using the triangular decomposition is -0.3% in the fourth year following the shock, compared to -1.5% in the third year under sign restrictions. Similarly, the fall in real house prices is about five times larger under sign restrictions.

Moreover, the confidence bands are tighter when the triangular decomposition is applied. Since the triangular decomposition is unique, there is no uncertainty stemming from the identification of the monetary policy shock. Thus, the confidence intervals exclusively reflect sampling uncertainty, which is related to the Bayesian estimation of the coefficients of the reduced–form VAR model. Under the sign restriction approach the uncertainty surrounding the impulse response functions increases due to the existence of multiple orthogonal decompositions of the variance–covariance matrix, which satisfy the imposed sign restrictions.

3 Heterogeneity Across Countries

So far, we have estimated the VAR model (1) for our sample of countries by assuming that systematic cross–country differences can be explained by country–

[6]Notice that the avoidance of the price puzzle – which is hard to explain on theoretical grounds – is one of the reason why we choose to use sign restrictions for the identification of the monetary policy shock.

specific intercepts. In the following, we proceed by splitting the countries into disjoint groups to reveal whether the economies are heterogeneous in the reaction of real house prices to a monetary policy shock.

3.1 Characteristics of Mortgage Markets

As emphasized by Maclennan, Muellbauer, and Stephens (1998) the institutional characteristics of mortgage markets across European countries constitute a source of heterogeneity for the role of housing in the transmission of monetary policy. Some key characteristics are summarized in Table 2, which depicts a number of institutional indicators that potentially have a bearing on the sensitivity of house prices to a change in interest rates (Calza, Monacelli, and Stracca, 2006).

Heterogeneity in the depth of mortgage markets across European countries is reflected by the volume of mortgage credit relative to GDP, which varies considerably. In the Netherlands, the United Kingdom and Denmark the ratios are relatively high, ranging between 111% and 67%, while Italy, Austria and France report the lowest ratios.

Table 2: Institutional Characteristics of Mortgage Markets

	Mortgage Debt (% of GDP)	Average Typical Term (years)	Typical LTV Ratio (in %)	Mortgage Equity Withdrawal	Refinancing (fee–free prepayment)	Interest Rate Adjustment	Mortgage Market Index
Austria	20	25	60	No	No	Mainly Fixed	0.31
Belgium	31	20	83	No	No	Mainly Fixed	0.34
Denmark	67	30	80	Yes	Yes	Mainly Fixed	0.82
Finland	38	17	75	Yes	No	Mainly Variable	0.49
France	26	15	75	No	No	Mainly Fixed	0.23
Germany	52	25	70	No	No	Mainly Fixed	0.28
Ireland	53	20	70	Limited	No	Mainly Variable	0.39
Italy	15	15	50	No	No	Mainly Fixed	0.26
Netherlands	111	30	112	Yes	Yes	Mainly Fixed	0.71
Portugal	53	28	75	No	–	Mainly Variable	–
Spain	46	20	80	Limited	No	Mainly Variable	0.40
Sweden	54	25	85	Yes	Yes	Mainly Variable	0.66
United Kingdom	73	25	70	Yes	Limited	Mainly Variable	0.58

Sources: IMF (2008), Calza, Monacelli, and Stracca (2006) and Tsatsaronis and Zhu (2004).

The access of households to mortgage credit depends on several factors (IMF, 2008), such as the standard length of mortgage loan contracts, the typical loan–to–value (LTV) ratio, the ability of mortgage equity withdrawals and the capability to prepay mortgages without fees. Longer mortgage debt contracts keep the ratio between debt services and income affordable. High LTV ratios allow households to take out more debt, while the ability to borrow against accumulated home equity allows households to tap their housing wealth directly. The possibility of early repayment enables households to refinance their mortgage debt in the event of an interest rate decline. Finally, the composition of mortgages between variable–rate and fixed–rate is also potentially important (Tsatsaronis and Zhu, 2004). Mortgage debt contracts designed with variable mortgage rates lower the debt burden of households when short–term interest rates decline, but at the expense of a higher burden when short–term interest rates rise.

The IMF (2008) distinguishes the development of mortgage markets across countries by means of a synthetic mortgage market index to exploit the diversity in explaining the role of housing for the transmission of monetary policy.[7] The index is constructed as a simple average of several institutional indicators and lies between 0 and 1, yielding that higher values reflect a high degree of development, while lower values indicate that the development is minor.[8]

According to the IMF (2008), mortgage markets in Denmark, Sweden and the Netherlands appear most developed, which suggests a high potential role for housing in the transmission of monetary policy. In these countries the standard length of mortgage debt contracts is around 30 years, the typical LTV ratios are about 80% and mortgage products specifically designed for equity withdrawals are widely marketed. In contrast mortgage markets in Austria, France, Germany and Italy appear less developed, as the typical LTV ratios ranges only between 50% to 70% and the ability of mortgage equity withdrawals is widely missing.

[7] Our discussion on the separation of countries refers mainly to the results of the IMF (2008), but we are aware of a number of studies – see Giuliodori (2005), Tsatsaronis and Zhu (2004) and Calza, Monacelli, and Stracca (2006), among others – that proceed along similar lines. These studies classify countries into homogenous groups taking account of several institutional indicators. Compared to the results of the IMF (2008), the outcome is akin.

[8] See IMF (2008) for details on the construction of the mortgage market index.

Nevertheless the distinction of countries by means of institutional indicators is disputable (Assenmacher-Wesche and Gerlach, 2008). First, the selection of the indicators is subjective. Vagueness prevails in the decision on which of the indicators are relevant. Second, the indicators are compiled arbitrarily. For instance a considerable degree of judgement is required – see ECB (2003) – to decide on the relevant LTV ratios (using the average ratio or the maximum ratio), to assess whether restrictions on early repayment fees are implemented or to evaluate whether mortgage rates are variable or fixed because both terms often coexist. Third, indicators for a particular country often point in the opposite direction concerning their role for the transmission of monetary impulses. While in Belgium, for example, the typical LTV ratio is above average, suggesting a relatively strong impact of interest rate changes on GDP, the prevalence of fixed–rate debt contracts or the impossibility of borrowing against home equity for consumption rather attenuate the transmission of monetary policy shocks. Since the classification of countries on the basis of institutional indicators suffers from these shortcomings, we decide to proceed by using an alternative approach, which lets the data decide whether housing and mortgage market heterogeneity is relevant for monetary policy transmission.

3.2 Country Clusters

Instead of following Assenmacher-Wesche and Gerlach (2008) and dividing our sample of countries a priori according to the country–specific institutional characteristics, we split our panel into two disjoint sub–panels – a *strong reaction group* and a *weak reaction group* – by focusing on the response of real house prices to a monetary policy shock. Since our approach is novel, we describe the methodology more explicitly.

3.2.1 Methodology

In principle, one can think of the reaction of real house prices to a monetary policy shock as a general function of the country–specific housing and mortgage market characteristics. This implies that the VAR parameters depend on these characteristics and, hence, the impulse responses differ from country to country.

Therefore, countrywise estimation would be optimal. Unfortunately, the precise estimation of impulse response coefficients within the VAR framework requires a relatively large number of observations. Since for the reasons outlined above a sensible sample does not start before 1995, we need to construct country panels in order to increase the number of observations by using the cross–section dimension. To facilitate an easy distinction between such country panels, we consider only two of them, namely a *strong reaction group* and a *weak reaction group*. Hence, the question we have to answer in this section is how to allocate the countries in our sample to one of these two groups. This is achieved in three steps.

1. Step: Define and Estimate the Distance between Sup–panels To quantify the difference between any two sub–panels of countries, we need to define a distance measure. As we are interested in the different impulse responses of real house prices after a monetary policy shock, we use

$$d = \left| \sum_{i=1}^{q} \alpha_{1i} - \sum_{i=1}^{q} \alpha_{2i} \right|, \tag{3}$$

where α_{1i} and α_{2i} are the median responses of real house prices of the first and second sub–panel, respectively, i periods after the occurrence of the shock. We consider the responses of up to $q = 2$ lags, which corresponds to the time period over which the sign restrictions are binding. Hence, the distance measure in expression (3) reflects the absolute value of the difference between the cumulated impulse responses over the first two quarters.

At first sight, it is now straightforward to allocate each country to either the *strong reaction group* or the *weak reaction group*. One can simply estimate all possible pairs of sub–panels and choose the pair with the largest distance. This approach resembles a cluster algorithm, where the number of clusters is fixed and the distance between the cluster centers (i.e., the impulse response coefficients) is maximized. However, we have to bear in mind that the impulse response coefficients are not observed but estimated. Hence, choosing the maximum distance pair only would contaminate the choice by a considerable portion of randomness. In fact, we find that there a many different pairs of sub–panels that exhibit similar distance measures.

Therefore, we proceed as follows. We estimate pooled VAR models for all possible pairs of sub–panels, which contain at least three countries to ensure enough degrees of freedom for each sub–panel.[9] Overall the number of pairs of sub–panels amounts to 4004.[10] For all pairs of sub–panels we generate impulse responses to a monetary policy shock, which is identified by imposing sign restrictions, and calculate the distance measure.

2. Step: Select Pairs of Sub–panels with Significant Distance Measure
Then, we identify all pairs of sub–panels that exhibit a significant distance measure, where significance is detected as follows. Assume that the estimated impulse response coefficients $\widehat{\alpha}_{1i}$ and $\widehat{\alpha}_{2i}$ asymptotically follow a normal distribution. Then the sums of the coefficients considered for the distance measure, denoted by $\widehat{s}_1 = \sum_{i=1}^{q} \widehat{\alpha}_{1i}$ and $\widehat{s}_2 = \sum_{i=1}^{q} \widehat{\alpha}_{2i}$, are also asymptotically normal. Under the null hypothesis that all pairs of sub–panels are identical and have the same sum of population coefficients $s = \sum_{i=1}^{q} \alpha_i$, the only systematic difference in the estimation results is the size of the panel from which they are estimated.

The sums of the estimated coefficients should be approximately distributed as:

$$\widehat{s}_1 - s \sim N\left(0, \sigma^2/(N_1 T)\right) \tag{4}$$

$$\widehat{s}_2 - s \sim N\left(0, \sigma^2/(N_2 T)\right), \tag{5}$$

where N_1 is the size of the first sub–panel, N_2 is the size of the second sub–panel, T is the number of observations corrected for the number of lags p in the VAR model and σ^2 is the population variance that is assumed to be constant across countries. Furthermore, assuming that the countries are independent, we can apply a classical two–sided difference test using the statistic: $d = \widehat{s}_1 - \widehat{s}_2$.

[9]As before the VAR models contain the same set of variables – real output, the overall price level, the short–term interest rate and real house prices – and a lag length of $p = 3$.

[10]Notice that in our panel the total number of disjoint pairs of sub–panels amounts to 4096 ($= 2^{13}/2$). Given that we consider only pairs of sub–panels containing at least three countries, this reduces the number of pairs to 4004, since there are one combination without any country, 13 combinations with only one country and 78 combinations – $(12 \times 13)/2$ – with two countries.

Under the null hypothesis, the statistic is approximately normally distributed with mean zero and variance:

$$\mathrm{Var}(d) = \sigma^2/(N_1 T) + \sigma^2/(N_2 T) = (1/N_1 + 1/N_2)\, \sigma^2/T. \tag{6}$$

Since σ^2 is unknown, we estimate the population variance from expression (6) by noting that:

$$\sigma^2 = T\mathrm{Var}(d)/\left(1/N_1 + 1/N_2\right), \tag{7}$$

where the sample variance of the distance measure $\mathrm{Var}(d)$ is calculated from the numerous realizations of d. Given the estimate of σ^2, we construct a t–statistic and compare it with the corresponding 95% critical value of the t–distribution.

As a result, we have identified all those pairs of sub–panels that are significantly different from each other. If there was no significant difference at all, we would conclude that all countries show the same house price response to a monetary policy shock and terminate the analysis here. However, we find 1900 significant distance measures. In contrast to using only the maximum–distance pair, we thus consider all the different ways to split the panel of countries into significantly different sub–panels. Thereby, we alleviate the problem that the impulse response coefficients, and hence the distance measure, are subject to estimation uncertainty. However, this approach in turn raises the question how to allocate a single country to either the *strong reaction group* or the *weak reaction group*.

3. Step: Allocate each Country to either the Strong or the Weak Reaction Group The allocation problem is tackled in the final step. Using the pairs of sub–panels with a significant distance measure we calculate the frequency that a specific country belongs to the sub–panels with the stronger reaction of real house prices to a monetary policy shock. If this frequency is above a threshold that is determined below, then the respective country is allocated to the *strong reaction group*, otherwise it is allocated to the *weak reaction group*.

The idea behind this rule is as follows. Assume there are three "true" strong reaction countries. Then we should expect that the distance measure is maximized when these three countries are put into one sub–sample and all the others in the other sub–sample. However, due to sampling error, a different pair of sub–samples may actually exhibit the largest distance. Using our approach, we may at least expect to find each of the three strong reaction countries to be more often in the strong reaction sub–sample than any of the other countries.

To accomplish this, we now derive the threshold for the frequency that a specific country belongs to the strong reaction sub–panels. From the previous step we know which pairs of sub–samples are significantly different from each other. Now we count how many times each country is in a strong reaction sub–sample. A priorily, each country has the same chance to be a strong reaction country. Hence, under this null hypothesis there is, for each pair of sub–panels, a 50 percent chance that a specific country is in the strong reaction sub–panel. Now assume that there are a total of N_c different pairs of sub–panels of which n exhibit a significant distance measure. Then, for each country, the number of times it is in the strong reaction sub–panel resembles a random experiment, where n draws without replacement are taken from a population of size N_c that is composed of 50 percent white (=strong reaction) and 50 percent black (=weak reaction) elements. Accordingly, the frequency x – that a particular country is found to be in the *strong reaction group* – follows a hypergeometric distribution: $f(x; N_c, N_c/2, n)$, where the number of pairs N_c depends on the total number of countries M and the minimum size of a sub–panel.[11]

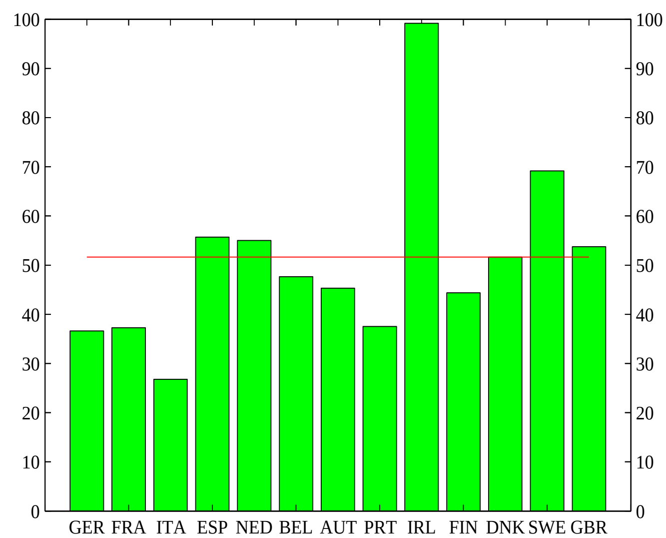
Finally, from the hypergeometric distribution we derive a 95% critical value for the frequency that a particular country belongs to the *strong reaction group*. If any country is selected more often, it is unlikely that this is due to pure chance. Hence, we allocate these countries to the *strong reaction group*. All other countries are allocated to the *weak reaction group*.

[11] Let us denote the the minimum size of a sub–panel by m. Then the number of possible pairs of sub–panels can be calculated as $N_c = \sum_{i=m}^{M-m} \begin{pmatrix} M \\ i \end{pmatrix}$. In our case, with $M = 13$ countries and a minimum sub–panel size of $m = 3$, we have $N_c = 8008$ pairs. Of these pairs, we have to estimate only $8008/2 = 4004$ because, e.g., the ordering of the pair $A = \{1,2,3,4,5,6\}, B = \{7,8,9,10,11,12,13\}$ or $A = \{7,8,9,10,11,12,13\}, B = \{1,2,3,4,5,6\}$ is irrelevant, while *ex ante* either A or B could be the strong reaction sub–panel.

3.2.2 Identified Country Groups

The separation of countries according to the above steps leads to two disjoint sub–panels that depart in the reaction of real house prices to a monetary policy shock. Figure 3 plots the relative frequency of belonging to the *strong reaction group* and the *weak reaction group* – as measured by means of the cumulative impulse responses of real house prices over the first two quarters – together with the critical value of the hypergeometric distribution, which amounts to 51.63%.

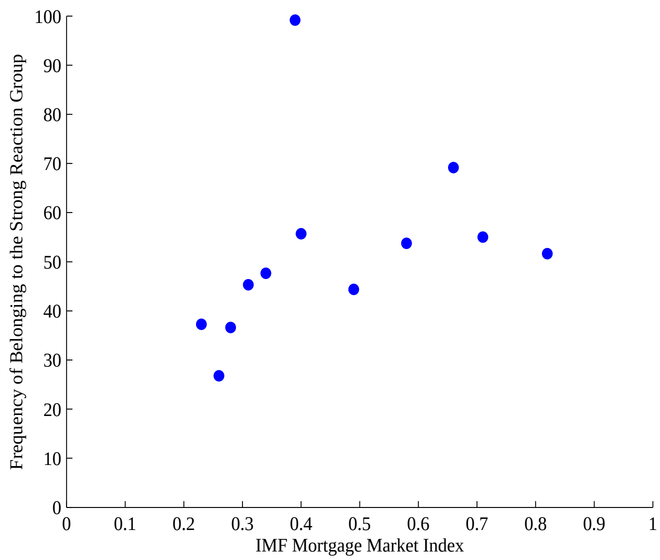
Figure 3: Frequency of Belonging to the Strong Reaction Group



Notes: The bars depict the frequency of belonging to the *strong reaction group* in percent. Out of the total of 4004 pairs of sub–panels, the number of disjoint sub–panels n, which show a significant distance measure, amounts to 1900 ($\widehat{=}$100%). The horizontal line shows the critical value of the hypergeometric distribution, which amounts to 51.63%. If the frequency is greater or equal than the critical value, the frequency with which a country appears in the *strong reaction group* is significant.

The classification of countries yields that Ireland, Sweden, Spain, the Netherlands, the United Kingdom and Denmark are settled in the *strong reaction group*, as in these countries the reaction of real house prices to a monetary policy shock is significantly more pronounced. In contrast Austria, Belgium, Finland, France, Germany, Italy and Portugal belong to the *weak reaction group* because their relative frequency is below the critical value.[12]

Figure 4: Comparison with IMF Mortgage Market Index



Our distinction of countries is roughly in line with the mortgage market index of the IMF (2008), however some important differences are in order (see Figure 4). First, the rankings of countries are different. We obtain for Ireland the highest relative frequency, followed by Sweden and Spain, while the mortgage market index assigns Denmark the highest value, followed by the Netherlands and Sweden. Second, the composition differs. We find that Ireland and Spain are settled in the *strong reaction group*, although both countries obtain relatively

[12]Our approach leads to the following ranking of countries as measured by the respective relative frequency: Ireland (99.16%), Sweden (69.16%), Spain (55.68%), the Netherlands (55.00%), the United Kingdom (53.74%), Denmark (51.63%), Belgium (47.63%), Austria (45.32%), Finland (44.37%), Portugal (37.53%), France (37.26%), Germany (36.63%) and Italy (26.79%). Notice that the 95% critical value of belonging to the *strong reaction group* is 51.63%.

low values in the mortgage market index. In turn, Finland obtains a relative high value in the mortgage market index, although this country belongs to the *weak reaction group*.

We interpret our findings as an indication that the development of mortgage markets across countries is important in shaping the reaction of house prices to a monetary policy shock, but additional country–specific characteristics – see ECB (2003) – such as national traditions, cultural factors, the share of the housing sector in overall economic activity, the number of employees in the construction sector, regulations regarding housing taxes and subsidies or transaction costs might also be relevant.

4 Assessing Heterogeneity across Countries

4.1 Baseline VAR models

What are the macroeconomic consequences of mortgage market heterogeneity across countries? To address this question we re–estimate a pooled VAR model for every sub–panel separately.[13] For both sub–panels, we compare the responses of the variables to a monetary policy shock, which is identified by imposing sign restrictions.

Figure 5 reports the impulse responses of the variables in both groups of countries – the *strong reaction group* and the *weak reaction group* – together with the confidence regions of the responses resulting from the estimation of the entire panel, which are marked by the shaded areas. While the median impulse responses of the two sub–panels are statistically not different from the median impulse responses of the entire panel, the differences are quantitatively significant. In both sub–panels real output falls after the monetary policy shock, but the decline in the *strong reaction group* is twice as large on impact (-3% versus -1.5%) and remains more pronounced for around two years. The fall of prices in the *strong reaction group* is also larger on impact (-2% versus -1%) and the price level remains below that of the *weak reaction group* until the end of the simulation horizon. The reaction of the short–term interest rate to a

[13] Again, every VAR model is estimated with a lag length of $p = 3$.

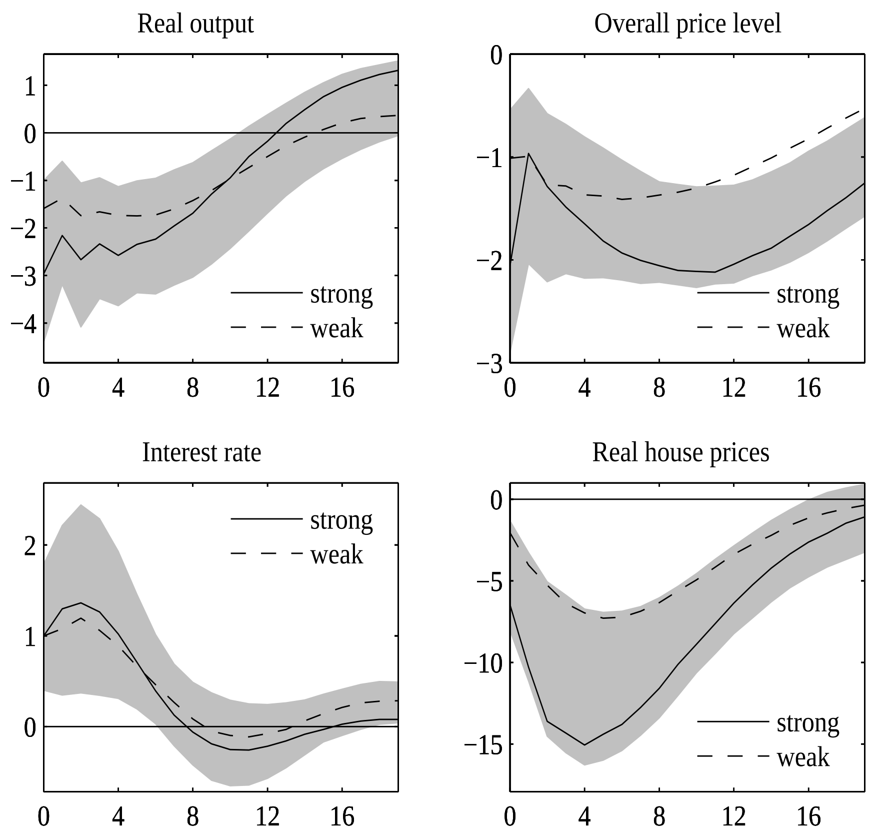
monetary policy shock is almost identical for both sub–panels, which ensures that the differences in the responses of the remaining variables in the VAR models are not due to a different evolution of the nominal interest rate.[14] The reaction of real house prices in both sub–panels also differs substantially as the drop in the *strong reaction group* is three times larger on impact (−6% versus −2%) and still twice as large after four quarters (−15% versus −7%) when the house price response reaches its trough.

For both sub–panels, Table 3 summarizes the forecast error variance decompositions, which provide an additional insight into the different quantitative impact of the monetary policy shock. Movements of real output are slightly more accounted for by the monetary policy shock in the *strong reaction group*, starting with 15% in the *strong reaction group* and 13% in the *weak reaction group* on impact of the shock and increasing up to 18% and 15%, respectively, at the end of the simulation horizon. Regarding the volatility of prices the differences between the two sub–panels are more obvious, as the monetary policy shock explains a share of 17% and 7% immediately after the occurrence of the shock, with a continuous increase to 39% and 32%. Likewise, movements in real house prices are more accounted for by the monetary policy shock in the *strong reaction group* than in the *weak reaction group*, starting with 14% and 8% on impact of the shock and increasing up to 34% and 26%, respectively, at the end of the simulation horizon.

The findings exhibit that the adjustment of the variables in both groups of countries depart – to some extent even substantially – after a monetary policy shock. The heterogeneity across countries seems to reflect the differences in the transmission of monetary policy, which can be related to the amplifying influence of house prices in propagating monetary policy shocks. We interpret the discrepancy in the adjustment as sizable enough to conclude that monetary policy should be concerned about movements in real house prices when setting interest rates.

[14] As before the monetary policy shock is normalized to unity, i.e. 100 basis points.

Figure 5: Impulse responses of country groups



Notes: The solid (dashed) lines denote the median of the impulse responses of the *strong (weak) reaction group*. The shaded areas refer to the 68% confidence intervals of the entire panel. All impulse response functions are identified from a Bayesian vector–autoregression with 1000 draws using sign restrictions. Real output, the overall price level and real house prices are expressed in percent terms, while the interest rate is expressed in units of percentage points at an annual rate.

Table 3: Forecast Error Variance due to a Monetary Policy Shock

	Real output		Overall price level		Interest rate		Real house prices	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Horizon								
1	15.08	12.77	17.07	7.20	10.80	16.66	14.11	7.58
2	16.35	11.35	14.75	9.14	9.20	14.32	22.49	13.11
3	17.33	11.97	15.43	12.21	8.63	12.82	27.25	15.66
4	17.92	12.54	16.64	14.24	8.74	11.81	29.91	18.12
6	18.47	14.72	20.62	19.01	9.25	10.58	33.48	21.55
8	18.18	16.74	25.36	22.90	9.81	10.20	34.41	23.50
10	17.55	17.25	29.90	26.00	10.92	10.59	34.79	24.74
12	16.96	16.95	33.54	28.46	11.59	10.92	34.58	25.35
14	16.63	16.07	36.09	30.55	12.23	11.23	34.34	25.92
16	16.79	15.64	37.41	31.26	12.54	11.48	33.94	25.66
18	17.50	15.37	38.00	32.18	12.83	11.69	33.85	25.61
20	18.59	15.40	38.59	32.44	12.99	12.08	33.88	26.05

Notes: For all variables the figures display the percent of the variance in the reduced form innovation at different horizons attributable to a monetary policy shock. (1) forecast error variance of the *strong reaction group*. (2) forecast error variance of the *weak reaction group*.

4.2 Extended VAR Models

In order to get a deeper insight in the way the monetary policy shock is transmitted to the macroeconomy, we estimate an extended pooled VAR model for both sub–panels, which includes an additional variable that potentially plays a role for the propagation mechanism. The matrix of endogenous variables is given by:

$$X_t = [y_t \;\; p_t \;\; s_t \;\; (hp)_t \;\; z_t]', \tag{8}$$

where (z_t) is the additional variable of interest, which is either given by real private consumption, real residential investment, the mortgage rate or the real effective exchange rate. The variables summarized by (z_t) are expressed in logs – except for the mortgage rate that is in percent – and linearly detrended.

The inclusion of private consumption by households follows from the idea that spending plans are likely affected by movements in house prices due to housing wealth and housing collateral effects (Muellbauer and Murphy, 2008). Households may increase their consumption expenditures in response to an increase in housing wealth induced by a shift of house prices.[15] Additionally, households may rise their consumption expenditures because of an easier access to credit, since an increase in house prices extends the value of collateral, which loosens credit constraints. The strength of both effects depends – inter alia – on the sensitivity of house prices to a change in interest rates. Residential investment may be stimulated by an increase in house prices, primarily because the value of housing rises relative to construction costs. Including the mortgage rate accounts for the speed with which debt contracts conditions adapt to a change in interest rates. The consideration of the real effective exchange rate allows to control for the effects arising through open economies influences that might also have a bearing on the transmission of monetary policy.

We assess heterogeneity across the two sub–panels by focusing on the reaction

[15] It is, however, important to note that an increase in housing wealth is different from a rise in financial wealth. As housing fulfills a dual role, serving as both a real asset and a commodity yielding service, an increase in the value of housing assets causes a redistribution of wealth within the household sector. Therefore the impact on consumption expenditure arising through wealth effects should be limited (**Quelle**).

of the additional variables to a monetary policy shock.[16] The impulse responses are plotted in Figure 6, together with the confidence regions of the responses resulting from the extended entire panel, which are marked by the shaded areas.

The findings exhibit that real private consumption in both sub–panels responds differently to a monetary policy shock, as the fall in the *strong reaction group* is more pronounced. This suggests that the reaction of private consumption is affected by the volatility of real house prices due to wealth and collateral effects. The response of real residential investment in both sub–panels seems to be alike, except for the reaction in the first year following the shock, which is more vigorous in the *strong reaction group* than in the *weak reaction group*.

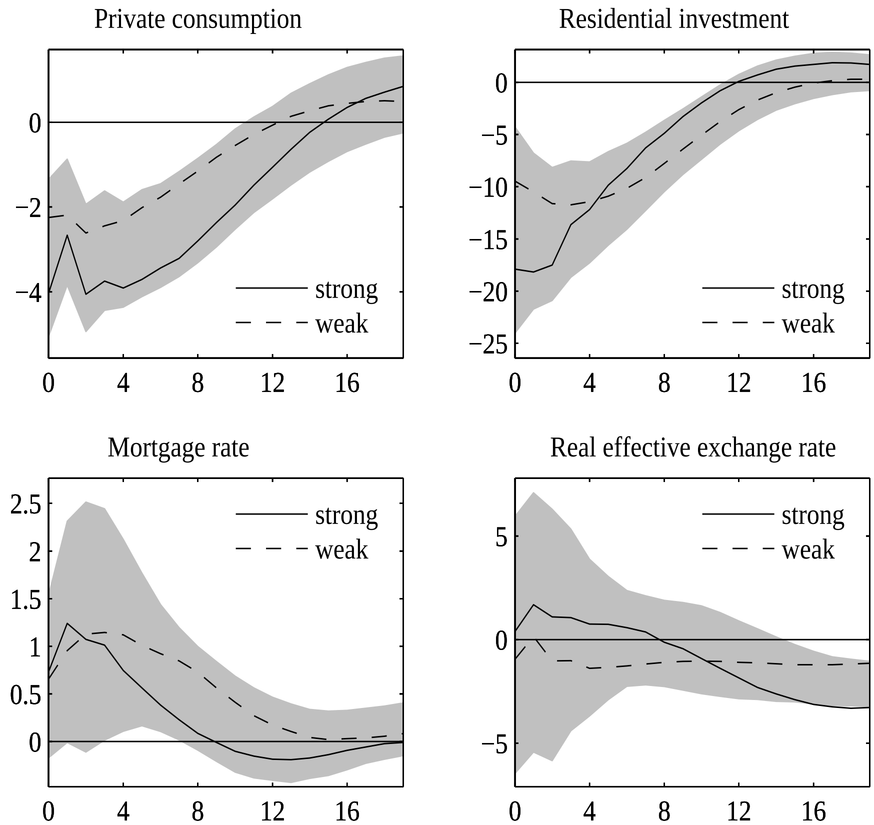
Mortgages rates in both sub–panels move differently. The increase in short–term interest rates is passed through faster to mortgage rates in the *strong reaction group*, yielding that the evolution of mortgage rates is very much in line with the short–term interest rate. By contrast, the adjustment in the *weak reaction group* is more persistent, indicating a slower pass–through of changed refinancing costs to mortgage rates. While this discrepancy in the adjustment of mortgage rates might be attributable to diverging debt contract terms, it turns out, however, that in the two sub–panels both, variable–rate and fixed–rate contracts, co–exist (see Table 2). Finally, the real effective exchange rate hardly moves in both groups after the monetary policy shock.

5 Concluding Remarks

We explore the role of housing and mortgage market heterogeneity in European countries for the transmission of monetary policy. We estimate a pooled VAR model to generate impulse responses of key macroeconomic variables to a monetary policy shock taking special account of the reaction of real house prices. Our sample comprises 13 countries for which we use quarterly data over the period from 1995 to 2006.

[16]To be consistent with the reaction of real output, we decided to include sign restrictions on the reaction of consumption and residential investment, which hold for two quarters. In contrast, the responses of the mortgage rate and the real effective exchange rate are left unrestricted.

Figure 6: Extended VAR Model Specifications



Notes: The solid (dashed) lines denote the median of the impulse responses of the *strong (weak) reaction group*. The shaded areas refer to the 68% confidence intervals of the entire panel. All impulse response functions are identified from a Bayesian vector–autoregression with 1000 draws using sign restrictions. Private consumption, residential investment and the real effective exchange rate are expressed in percent terms, while the mortgage rate is expressed in units of percentage points at an annual rate.

We find that key macroeconomic variables in European countries co–move with real house prices after a monetary policy shock. In order to assess the impact of housing and mortgage market heterogeneity across countries we split our sample into two disjoint groups – a *strong reaction group* and a *weak reaction group* – using a data–driven approach that takes account of the reaction of real house prices to a monetary policy shock. This is in contrast to the existing literature – notably to Assenmacher-Wesche and Gerlach (2008) – which typically splits the panel exogenously using a broad range of indicators that reflect cross–country differences in the structure of housing and mortgage markets.

A comparison of the impulse responses of the two groups yields that quantitatively significant differences exist. The reaction of macroeconomic variables in the *strong reaction group* (including Ireland, Sweden, Spain, the Netherlands, the United Kingdom and Denmark) is more pronounced than in the *weak reaction group* (including Austria, Belgium, Finland, France, Germany, Italy and Portugal), which suggests that real house prices play an amplifying role in the propagation of monetary policy shocks. Our result stands in contrast to Assenmacher-Wesche and Gerlach (2008) who find that institutional characteristics of mortgage markets across countries shape the response of house prices to monetary policy shocks, but the differences between the groups are quantitatively unessential. As regards the discrepancies of the responses of major macroeconomic variables after a monetary policy shock across our groups of countries, we conclude that monetary policy should take account of the volatility of real house prices when setting interest rates.

Appendices

A Data Base

We use data for 13 European countries taken from the OECD over the period from 1995Q1 to 2006Q4. The sample of countries includes Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. The data comprises:

1. Real GDP: Gross domestic product, volume, market prices, seasonally adjusted.

2. Prices: Gross domestic product, deflator, market prices, seasonally adjusted. An exception is Ireland where the consumer price index is used, since the GDP deflator exhibits ... (?)

3. Short–term interest rate: Short-term interest rate in percent.

4. Real house prices: Nominal house prices provided by the OECD, deflated with the GDP deflator, seasonally adjusted.

5. Real private consumption: Private final consumption expenditure, volume, seasonally adjusted.

6. Real residential investment: Private residential fixed capital formation, volume, seasonally adjusted. Since residential investment is not available for Austria, Portugal and Spain, we used the gross fixed capital formation, volume, seasonally adjusted, instead.

7. Mortgage rates: Mortgage rates taken from the European Central Bank (www.ecb.org).

8. Real effective exchange rate: Real Effective Exchange Rate Index, EUR.

B Tests for Serial Correlation

References

Assenmacher-Wesche, K., and S. Gerlach (2008): "Ensuring Financial Stability: Financial Structure and the Impact of Monetary Policy on Asset Prices," CEPR Discussion Paper 6773, Centre for Economic Policy Research.

Calza, A., T. Monacelli, and L. Stracca (2006): "Mortgage Markets, Collateral Constraints, and Monetary Policy: Do Institutional Factors Matter?," CEPR Discussion Paper 6231, Centre for Economic Policy Research.

Canova, F., and G. de Nicolo (2002): "Monetary Disturbances Matter for Business Fluctuations in the G-7," *Journal of Monetary Economics*, 49, 1131–1159.

Canova, F., and J. Pina (2005): "What VAR Tell us about DSGE Models," in *New Trends in Macroeconomics*, ed. by C. Diebolt, and C. Kyrtsou, pp. 89–124. Springer.

ECB (2003): "Structural Factors in the EU Housin Markets," Structural issues report, European Central Bank.

Faust, J., and E. Leeper (1997): "When Do Long Run Identifying Restrictions Give Reliable Results?," *Journal of Business and Economic Statistics*, 15(3), 345–353.

Girouard, N., and S. Blöndal (2001): "House Prices and Economic Activity," OECD Economics Department Working Papers 279, OECD Economics Department.

Giuliodori, M. (2005): "Monetary Policy Shocks and the Role of House Prices across European Countires," *Scottish Journal of Political Economy*, 52, 519–543.

Goodhart, C., and B. Hofmann (2008): "House Prices, Money, Credit, and the Macroeconomy," *Oxford Review of Economic Policy*, 24, 180–205.

Iacoviello, M. (2002): "House Prices and the Business Cycles in Europe: A VAR Analysis," Boston College Working Papers in Economics 540, Boston College Department of Economics.

——— (2005): "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, 95, 739–764.

Iacoviello, M., and R. Minetti (2003): "Financial Liberalisation and the Sensitivity of House Prices to Monetary Policy: Theory and Evidence," *The Manchester School*, 71, 20–34.

Iacoviello, M., and S. Neri (2007): "Housing Market Spillovers: Evidence from an Estimated DSGE Model," Boston College Working Papers in Economics 659, Boston College Department of Economics.

IMF (2008): *World Economic Outlook April 2008*. International Monetary Fund, New York.

Maclennan, D., J. Muellbauer, and M. Stephens (1998): "Asymmetries in Housing and Financial Market Institutions and EMU," *Oxford Review of Economic Policy*, 14, 54–80.

Mishkin, F. S. (2007): "Housing and the Monetary Transmission Mechanism," Finance and Economics Discussion Series 2007-40, Board of Governors of the Federal Reserve System (U.S.).

Monacelli, T. (2009): "New Keynesian Models, Durable Goods, and Collateral Constraints," *Journal of Monetary Economics*, forthcoming.

Muellbauer, J., and A. Murphy (2008): "Housing Markets and the Economy: The Assessment," *Oxford Review of Economic Policy*, 24, 1–33.

Pariès, M. D., and A. Notarpietro (2008): "Monetary Policy and Housing Prices in an Estimated DSGE Model for the US and the Euro Area," Working Paper Series 972, European Central Bank.

Peersman, G. (2005): "What Caused the Early Millennium Slowdown? Evidence Based on Vector Autoregressions," *Journal of Applied Econometrics*, 20, 185–207.

Sims, C. A. (1980): "Macroeconomics and Reality," *Econometrica*, 48, 1–48.

——— (1992): "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy," *European Economic Review*, 36(5), 975–1001.

Tsatsaronis, K., and H. Zhu (2004): "What drives House Price Dynamics: Cross–Country Evidence," *BIS Quarterly Review*, March, 65–79.

Uhlig, H. (2005): "What are the Effects of Monetary Policy on Output? Results from an Agnostic Identifcation Procedure," *Journal of Monetary Economics*, 52, 381–419.