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# Do House Prices Impact Consumption and Interest Rates? Evidence from OECD Countries using an Agnostic Identification Procedure[1]

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## Abstract

This paper investigates the existence of significant spillovers from the housing sector onto the wider economy for eight OECD countries in a six-variable structural vector autoregressive model (SVAR). A housing demand shock is identified through the recursive Choleski decompostion and, subsequently by using Uhlig's (2005) agnostic identification procedure. The latter allows a housing demand shock to be identified by imposing sign restrictions on the impulse responses of consumer prices, residential investment, real house prices and mortgage loans, while private consumption and nominal interest rate responses are left unrestricted. The results suggest that consumption responds positively and significantly to a house price shock in Canada, France, Japan, Spain and, the UK. A significant positive delayed response of nominal interest rates follows a house price shock in Germany, Japan, the UK and, the US, suggesting that while central banks do not seem to respond instantly and systematically to a housing demand shock, its repercussions on the economy tend to translate into higher policy rates after a few quarters.

*Keywords: House Price, Monetary Policy, Consumption, Agnostic Identification*

*JEL Classification: C32; E31; E32; E44; E52*

## 1. Introduction

Housing markets have a significant influence on macroeconomic developments in OECD countries and are therefore bound to influence policies and in particular

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monetary policy. The extent to which house price shocks spillover to the wider economy varies, however, with country specific structures, such as the organisation of the mortgage market and rules governing land use. While house prices are likely to influence monetary policy directly or indirectly, they are only one of the numerous parameters likely to influence central banks' decisions. Hence, empirical analysis is needed to assess the strength of house price spillovers and policy reactions. A structural VAR model allows to capture the main transmission channels in a parsimonious way. Residential investment responds to rising house prices, with multiplier effects as construction generates income and employment. Expanding housing markets can boost private consumption though several channels. Purchases of durable goods tend to accompany acquisitions of dwellings. More importantly, higher house prices produce wealth and collateral (or liquidity) effects. In theory, at the aggregate level, increases in housing wealth are offset by higher discounted value of future imputed rents (Buiter 2008). Nevertheless, redistribution of wealth across households with different propensities to consume can affect the level of household spending (Catte *et al*. 2004). Moreover, housing wealth is often used as collateral to secure loans used to finance consumption.[2] Rising residential investment and private consumption lift aggregate demand, which may lead monetary authorities to intervene to prevent overheating. Rising mortgage debt may also threaten financial stability, providing another rationale for monetary policy intervention.

A number of papers show a strong link between the housing market and economic activity in the United States (see for example Green 1997, Iacoviello 2005, Case *et al.* 2005, Leamer 2007, Jarocinski and Smets 2008, Vargas-Silva 2008, Pavlidis *et al.* 2009, Ghent and Owyang 2010, Iacoviello and Neri 2010, Calza *et al.* 2013 and, Miller *et al.* 2011) and some other countries (see for example Muellbauer and Murphy 2008, Bassanetti and Zollino 2010, Bulligan 2010 and, Das *et al.* 2011). However, international studies on the subject are sparse. The few exceptions that we are aware of include Ludwig and Sløk (2004), Goodhart and Hofmann (2008) and, Musso *et al.* (2011). Goodhart and Hofmann (2008) focus on monetary policy (mortgage), credit supply and housing demand shocks and compare the impulse responses in a panel of seventeen industrialized countries, Musso *et al.* (2011) provide a transatlantic comparison of responses to shocks in the US and the aggregate euro economy based on a structural VAR (SVAR) and, Ludwig and Sløk (2004) take a panel cointegration approach for sixteen OECD countries to investigate links between stock and house prices and private consumption.[3]

Against this backdrop, using quarterly data, our paper analyzes whether real house price movements have significant spillover effects on consumption decisions

2 The collateral (or liquidity) effect is difficult to separate from a wealth effect in practice. However, the fact that housing wealth effects are strongest in countries with sophisticated mortgage markets tends to confirm the prevalence of the collateral effect.

3 Another strand of the literature focuses on international spillovers (see for example Otrok and Terrones 2005, Vansteenkiste and Hiebert 2009 and, de Bandt *et al.* 2010).

in eight OECD countries, namely, Canada (1970:01–2011:04), France (1978:01–2008:04), Germany (1970:01–2011:04), Italy (1975:01–2010:04), Japan (1970:01–2010:04), Spain (1980:01–2011:04), United Kingdom (UK, 1970:01–2011:04) and, the United States (US, 1970:01–2011:04). For our purpose, we use a six variable vector autoregressive (VAR) framework comprising the price level, private consumption, residential investment, nominal interest rate, house price and mortgage loans. The housing demand shock is identified via Uhlig's (2005) approach, which imposes theoretically consistent sign restrictions on some variables for a certain duration. The responses of the variables of interest are, however, agnostically left open.[4] These six variables are chosen to appropriately identify a housing demand shock, and are also in line with the work of Musso *et al.* (2011). Given this, the choice of these eight countries and their respective sample periods are purely driven by the availability of data for these six variables included in the VAR.

The decision to use an agnostic approach to identify a housing demand shock over and above the popular recursive (i.e., Cholesky) identification scheme, as used in Musso *et al.* (2011), emanates from the theoretically inconsistent behavior of the impulse response functions (IRFs) in some cases following a house price shock, details of which are presented in Section 3.2.1. It must be pointed out that theoretically inconsistent results in small-scale VAR systems, identified using the recursive scheme are very common in the literature. Walsh (2000) indicates that this is mainly due to the limited information captured by small-scale VARs, which are not rich enough to properly identify the true dynamics of the macroeconomy following a specific type of shock.[5] Having said that, it is not always the case that sign restrictions are superior to short-run quantitative restrictions in delivering shocks that are structurally interpretable. Fry and Pagan (2010) state that: "It should probably not be surprising that one cannot recover the correct elasticities simply by the use of sign restrictions, since sign restrictions are very weak information. But the literature largely treats them as if they are capable of recovering accurate quantitative information. [. . .] there is no reason to suppose that sign restrictions are better than any other way of eliciting information on impulse responses, such as provided by short run or long run restrictions." Furthermore, as indicated by Musso *et al.* (2011), sign

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4 Please refer to Section 2 for further details.

5 Two alternatives to the sign-restriction approach are to use the factor-augmented VAR (FAVAR) and large-scale Bayesian VAR (LBVAR) models, which allows for large number of variables in the models, and hence, a large information set to mimic the true dynamics of the economy. For detailed discussion of these approaches and their application dealing with the effect of a monetary policy shock on a whole host of housing market variables at national and regional levels, see Gupta, Jurgilas and Kabundi (2010), Gupta and Kabundi (2010), Gupta, Jurgilas, Miller and van Wyk (2012) and, Gupta, Jurgilas, Kabundi and Miller (2012). These two approaches involve acquiring data on large number of variables (generally over one hundred), which would naturally lead to lot of heterogeneity amongst the countries in terms of the variables chosen. Since it would be difficult to obtain the same set of so many variables across the countries, we decided to resort to the sign-restriction approach based on the same (or similar) six variables.

restrictions should preferably be derived from a Dynamic Stochastic General Equilibrium (DSGE) model. However, it is also true that there is much more consensus on how to identify monetary policy and housing demand shocks compared to, for example, credit supply shocks (Musso *et al.* 2011).

Our paper provides results from both the recursive identification scheme (allowing the data to "speak for themselves") and the sign-restriction approaches, and motivates the decision to rely on the results from the latter methodology by its ability to provide a theoretically consistent behavior of the variables under consideration. Identification restrictions may be derived from a structural VAR model. However, to identify all the shocks properly, structural models require many restrictions. For instance, the identification of six structural shocks in a six-variable VAR, as we use, requires as many as: (6X5)/2=15 parameter restrictions. Since, in this study we want to identify a housing demand shock only, we rely upon the sign restriction scheme, which helps us achieve our objective without requiring us to identify the other shocks in the system. In addition, the identification of a housing demand shock using the sign restriction procedure has the advantage of distinguishing a housing demand shock from other types of shocks including aggregate demand, monetary policy and fiscal policy shocks, which could yield similar behaviour of the variables in the system. Furthermore, given that the structural identification is based on orthogonalized matrices drawn randomly within a Bayesian framework, the ordering of the variables in the VAR does not affect the nature of the impulse responses, as is commonly observed with the Choleski identification scheme. Finally, the sign-restriction approach also allows for immediate responses of the relevant variables following a shock, thus mitigating the issue of enforced/presumed delayed effects under the recursive approach, under which variables are ordered based on our prior belief on whether, following a shock on a specific variable, other variables in the system would react contemporaneously (known as *fast moving variables* and are ordered after the variable subject to the shock) or with a delay (known as *slow moving variables* and are ordered before the variable subject to the shock).

In addition to studying the response of private consumption to a house price shock, our model allows the response of short-term interest rates to this shock to be examined. The question of the response of monetary authorities to developments in house prices seems to have gained prominence among academics, especially in the wake of the recent financial crisis. It seems logical for central banks to react to house price shocks insofar as they affect economic activity and inflation. But some economists advocate a more active role for monetary policy in preventing the development of bubbles that can be costly in terms of future output and financial stability (e.g., Roubini 2006). Others argue that monetary policy is not the appropriate instrument to deal with asset bubbles (e.g., Posen 2006), or, as indicated by Hott and Jokipii (2012), based on evidence from fourteen OECD countries, that in order to lean against house price fluctuations it is not necessary to consider house prices directly in monetary policy decisions, if interest rates are set at similar levels to those implied by the Taylor rule (thus reducing deviations of house prices from their fundamental value). In some countries, central banks have occasionally referred to house prices as one of the parameters influencing monetary policy decisions (e.g., Australia, Sweden, United Kingdom). As central banks generally examine a wide set of economic variables to inform their policy decisions, it is difficult in practice to determine whether house prices play a role in interest rate setting.

A number of recent studies (Castro 2011, Naraidoo and Ndahiriwe forthcoming and, Naraidoo and Raputsoane 2010 amongst others) have developed financial conditions indices (FCI), which include house prices amongst other financial variables, and have analyzed the importance of the FCI using linear and non-linear Taylor (1993)-type rules in the euro area, the UK, US and South Africa. These studies tend to show that, apart from the US Federal Reserve, central banks have systematically reacted to the FCI, more so during the current financial crisis. Darracq Pariès and Notarpietro (2008) and, Finocchiaro and von Heideken (2009) analyze whether house prices play a role in the interest-setting behaviour of central bankers using DSGE models, explicitly accounting for a housing sector, in the US and euro area, and Japan, the UK and the US, respectively. Their results suggest that trying to address the endogeneity problem in stand-alone monetary policy reaction functions augmented with house prices using General Method of Moments (GMM) methods produces biased and dispersed estimates. Thus, there are concerns using single-equation Taylor (1993)-type models. Furthermore, the studies using an FCI, which is a composite of four or five asset-related variables, do not specifically indicate the role of house prices in the monetary policy reaction functions. The studies using DSGE models tend to reach similar conclusions to those based on an FCI regarding the non-responsiveness of the Federal Reserve to house price movements.

Some evidence of simultaneous interest rate response to house price shocks in Sweden and the UK have been provided by Bjørnland and Jacobsen (2010) based on SVAR models, with monetary policy shocks being identified on the basis of a combination of both short- and long-run restrictions. Musso *et al.* (2011) obtain similar results for the aggregate euro area and once again confirm the lack of immediate interest rate response to house price shocks in the US. In light of the importance of this question, and given the structure of our framework, we also analyzed, over and above the spillover effect on consumption, whether house price shocks result in simultaneous response in the monetary policy instrument, or whether the response is a delayed one following inflationary pressures due to an increase in aggregate demand resulting from multiplier and wealth effects of a positive shock on real house prices.

The international evidence on the interest rate response to a house price shock is limited to the euro area, Japan, the UK, and the US. Hence, our paper also adds to these studies by analyzing the question of interest rate response to house prices for a wider set of countries. To the best of our knowledge, this is the first attempt to compare the issue of spillover of housing demand shocks on consumption and interest setting behaviour in eight major OECD countries based on both the recursive and sign-restriction identification schemes. The remainder of the paper is organized as follows: Section 2 discusses the ordering of the variables for the recursive identification scheme and provides the basics of the agnostic approach. Section 3 discusses the data and presents the results from the two alternative methods identifying the housing demand shock. Finally, Section 4 concludes.

## 2. Methodology

Following Uhlig (2005), this paper estimates a VAR model of the form:

$$Y_t = B_{(0)} + B_{(1)} Y_{t-1} + B_{(2)} Y_{t-2} + \ldots + B_{(l)} Y_{t-l} + u_t, \quad t = 1, \ldots, T. \tag{1}$$

where:

$Y_t$ represents a *mx1* vector of endogenous variables at time $t = 1, \ldots, T$. In our case, $Y$ contains six variables: consumer price level ($p$), private consumption ($c$), residential investment ($ri$), nominal interest rate $i$), house price ($hpr$) and real mortgage loans ($b$). $c$, $ri$, $hpr$ and $b$ are expressed in real terms (generated by dividing the nominal values of each series by the private consumption deflator), and all variables are in their logarithmic-form, except the nominal interest rate.[6] The optimal lag length is determined on the basis of the Akaike Information Criterion (AIC).[7] At any date $t$ we therefore have,

$$Y = [p, c, ri, i, hpr, b]' ; \tag{2}$$

$B_0$ is $mx1$ vector of constants; $B_{(j)}$ $j = 1, \ldots, l$ represent $mxm$ coefficient matrix; $u_t$ represents the one-step ahead prediction error with variance-covariance matrix $\sum$.

As indicated in the introduction, we first analyzed the impulse response functions by trying to identify the housing demand shock using a recursive or Choleski identification scheme. For this purpose, following Musso *et al.* (2011), the variables were ordered as indicated in equation (2). In this regard, note that the equation for the real house price can be interpreted as a housing demand function, which, in turn, relates the real house price to consumption and residential investment. As in Jarocinski and Smets (2008), Iacoviello and Neri (2010) and, Musso *et al.* (2011), a non-monetary housing demand shock is such that an increase in real house prices leads to a rise in residential investment through time without being associated with a fall in the monetary policy instrument, so that we can distinguish the shock from an expansionary monetary policy shock. Further, it is assumed that consumption does not

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[6] Please refer to Section 3 for full details regarding the data used for these six variables.

[7] The obtained optimal lag-lengths for the specific countries were as follows: Canada: 6; Germany: 5; France: 8; United Kingdom: 2; Italy: 3; Japan: 8; and, the United States: 2.

react simultaneously to this shock, so that the shock cannot be dubbed a positive technology shock, including of the "positive news" type shock.[8]

The impulse responses from a VAR are highly non-linear functions of these coefficients. Hence, to properly assess the statistical significance of the generate point values, Monte Carlo integration needs to be applied to examine the distribution of the coefficients. In this regard the impulse response functions are generated by imposing a diffuse (Jeffrey's) prior on the VAR, i.e., $F(B, \Sigma) \propto |\Sigma|^{-(m+1)/2}$, besides the basic Choleski factorization to identify the housing demand shocks. In addition, we use antithetic acceleration by drawing a new value of $\Sigma$ and $B$ on the odd draws and then flipping $B$ around the mean of the posterior (Ordinary Least Squares (OLS) estimates) on the even draws. Following Uhlig (2005), in all the impulse response plots, that is for the recursive identification scheme and the sign-restriction approach, we show the median as well as the 16 percent and the 84 percent quantiles for the sample of impulse responses.

As will be indicated below, due to theoretically inconsistent results at times obtained from the Choleski identification scheme, to study the effect of house prices on consumption and the nominal interest rate, this paper also uses Uhlig's (2005) agnostic identification procedure by imposing sign restrictions for a specific period of time (4 quarters)[9] on the responses of all variables in the VAR except private consumption and the nominal interest rate (our two variables of interest). To ensure that the house price shock corresponds to a housing demand shock, we impose non-negative sign restrictions on $p$, $ri$, $hpr$ and $b$, and leave $c$ and $i$ unrestricted.[10]

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8 Besides the studies of Ludwig and Sløk (2004), Goodhart and Hofmann (2008), Das *et al.* (2011) and, Musso *et al.* (2011) discussed in the introduction as providing international evidence on the spillover effect of house price shock, Aspachs-Bracons and Rabanal (2011) indicate significant effects of Spanish house price shocks on consumption and residential investment in a VAR. In this model, the housing demand shock was identified as the shock that affects house prices within a period, after taking into account the effect that changes in the interest rate have on house prices. However, the results of this paper also indicated a persistent decline in the interest rate. Thus, as indicated in Musso *et al.* (2011), we cannot distinguish the shock from an expansionary monetary policy shock, and, hence, cannot place too much confidence on these results. Demary (2010) also provides some evidence on the effect of a house price shock on output and interest rate in ten OECD countries based on a SVAR model with shocks identified using the Choleski scheme. However, with no confidence bands provided for the impulse response analysis, it is not possible to judge the significance of the effect of house price shocks on Gross Domestic Product (GDP) and interest rate.

9 We followed Uhlig (2005) in restricting the impulse responses over four quarters—a standard practice for quarterly data. However, we also carried out a robustness check of our results by restricting the impulse responses for one quarter only. The obtained results are qualitatively similar to those based on the restriction for a year. This is not surprising, given the high degree of persistence in house prices. These results are available upon request from the authors.

10 Musso *et al.* (2011) used the mortgage lending rate in addition to the six variables we use, since they also analyze a credit supply shock, besides monetary policy, house price, and residential investment shocks. Our results are qualitatively similar if we include the mortgage lending rate in our VAR model. These results are available upon request from the authors. However, we feel that our choice of six variables is enough to identify the house price shock

Uhlig's (2005) agnostic identification procedure can be described as follows[11]: we want to define a house price (housing demand) shock impulse vector as one in which the sign restrictions hold. In other words, a house price shock impulse vector is such that the responses of prices, residential investment, and mortgage loans are non-negative at all horizons $k = 0, \ldots, K$. Furthermore, to account for identification issues, Uhlig (2005) recommends supplementing the above-mentioned identification assumptions by imposing a prior, which, in turn, is proportional to a Normal-Wishart (Uhlig, 1994). Empirically, the following steps are carried out:

1. take $n_1$ draws from the VAR posterior and $n_2$ draws from an independent uniform prior;
2. determine the impulse vector;
3. at horizon $k = 0, \ldots., K$, compute the impulse response functions (IRF) for each draw;
4. verify whether the IRF comply with the sign restrictions;
5. keep the draw when all the IRF comply with the sign restrictions. Reject the draw in case any of the IRF does not satisfy the sign restrictions;
6. stop the process after acquiring $n_3$ IRF with the required sign. The error band computations are based on the draws used.

This paper uses $n_1 = n_2 = 200, n_3 = 1000$ and $K = 3$ in the estimations.

## 3. Data and Results

### 3.1 Data

As there is no international harmonised dataset of house prices, series have been selected among various available national data sources, in most cases government bodies. Whenever the frequency of the original data is semi-annual or annual, quarterly series have been derived through interpolation.[12] The series are thought to be the most representative of the entire national market for existing homes and are among the most closely monitored by policymakers. However, one needs to bear in mind that the methodologies and the coverage of these series vary widely. Series

we are interested in appropriately. Interestingly, we observed that if we theoretically restrict the response of the mortgage lending rate to a house price shock, the monetary policy instrument behaves in the same way.

11 Please refer to the original source for further details.

12 The use of interpolated series is imposed by the lack of reliable quarterly data over on long sample in Germany, Italy and Japan. The original series are semi-annual for Italy and Japan and annual for Germany, and have been converted to quarterly through linear interpolation. While relying on interpolated data is clearly sub-optimal, the problem is mitigated by the strong inertia generally displayed by house prices.

differ in terms of transaction mix and quality adjustment. An average or median price index is affected by the share of various types of homes in transactions. To overcome this problem, mix-adjusted, repeat-sales or hedonic indices are produced in some countries. Coverage varies from most transactions in the country to selected transactions (e.g., certain types of dwelling, homes financed through conventional mortgages) or metropolitan areas.

For Canada, we use the Canadian Multiple Listing Service average resale price index, which has a national coverage but no mix or quality adjustment. The French index is produced by the national statistical institute INSEE using data from notaries covering the vast majority of transactions in the country. It is adjusted for quality using a hedonic method. The German index is produced by the Bundesbank using data from the real estate consultant BulwienGesa. Its coverage is limited to cities, but it is partially adjusted for the transaction mix. For all variables for Germany, pre-reunification data (before 1991) only cover West Germany. The Italian economic research institute Nomisma produces an index of average house prices in 13 urban areas on a semi-annual basis, which is also partially adjusted for the transaction mix. No long-term country-wide house prices series is available for Japan. The best proxy is the semi-annual urban land price index produced by the Japan Real Estate Institute.[13] The Bank of Spain publishes a national series of mix-adjusted average housing prices for dwelling more than two years old. The UK Department for Communities and Local Government produces a mix-adjusted price index, covering the whole country. The US Federal Housing Finance Agency (FHFA) produces a repeat sales index with the widest geographical coverage, which however excludes housing financed by non-conventional mortgages.

Most of these series do not go back to the 1970s. The length of the housing cycle, about 10 years from peak to peak, and the data requirement of VAR models impose a large sample. Therefore, series have in most cases been extended using unpublished data from the Bank for International Settlements. House price series have been seasonally-adjusted when relevant and deflated by the private consumption deflator.

Mortgage loans series (outstanding amounts of household mortgage debt) have been compiled by the OECD using information from central banks and national accounts balance sheets. They have been deflated using the private consumption deflator.

The source for other variables is the OECD Economic Outlook database. Private consumption and residential investment volumes are standard national accounts variables. The consumer price index is the private consumption deflator, which is more homogeneous over long time periods than the headline CPI published by na-

13 The lack of reliable long-term house prices series in Japan is a limitation to the analysis and comparability with other countries. However, the share of land in Japanese housing wealth is around three quarters and land is usually the most volatile determinant of house prices (Catte *et al*. 2004). This justifies the inclusion of Japan in this article.

tional authorities (hereafter, CPI refers to the private consumption deflator). The nominal interest rate is the 3-month money market rate. It is worth noting that while all countries in the sample have experienced changes in monetary policy regimes since the 1970s, the creation of the Euro in 1999 constitutes a radical transformation for the countries involved. Table A1 in the Appendix provides a summary statistics of the variables used for each of the eight OECD countries. In addition, data plots are also provided in the Appendix in Figures A1 to A6 for the six variables of each of the countries.

Note that all variables except the interest rate are in log-levels. Sims *et al.* (1990) indicate that with the Bayesian approach entirely based on the likelihood function, the associated inference does not need to take special account of nonstationarity, since the likelihood function has the same Gaussian shape regardless of the presence of nonstationarity.

## 3.2 Results

### *3.2.1 Impulse Responses using a Choleski (Recursive) Identification Scheme*

Impulse responses to a housing demand shock of one standard deviation of the innovation generally show expected features, though not for all variables in all countries (Figures 1 to 8). Real house prices increase in the quarters following impact from 0.3% to 1.5% depending on countries and fall back very slowly to their baseline, reaching it after 4 to 5 years. Such a pattern is consistent with strong autocorrelation in house prices, resulting in part from extrapolative expectations (Cho 1996), and the observed cycles of about 10 years from peak to peak (André 2010). Higher housing demand is associated with an increase in real mortgage loans. One exception is Japan, where the fall in real mortgage lending suggests that the Choleski identification scheme is unable to properly identify a housing demand shock. In France, the mortgage loan becomes significant only after about two years, which is also hardly compatible with a pure housing demand shock.

A housing demand shock can affect private consumption through several channels. First, a rise in residential investment produces multiplier effects on employment and income, albeit not a very large one as residential investment only represents 5% of GDP on average across countries and time. Housing investment rises significantly in every country except Germany, with the highest responses in Canada, France, Italy, Spain and the UK. The response in the US is more muted, even taking into account the smaller magnitude of the shock. The muted response of residential investment to a house price shock is unexpected, as the responsiveness of housing supply to demand is estimated to be high in the US (Meen 2002, Swank *et al.* 2002, Caldera Sánchez and Johansson 2011). Second, there are a wealth and collateral effects. As house prices increase, more collateral is available to secure mortgages, loosening the borrowing constraint of households (Aoki *et al.* 2002 and, Muellbauer and Murphy 2008). This housing wealth or collateral effect is expected to be stronger in countries with more sophisticated mortgage markets, proposing products that allow housing equity withdrawal.[14] Third, increases in inflation and interest rates could offset part of the investment and wealth effects.

The initial private consumption response is roughly as expected in Canada and the UK, as housing wealth effects on private consumption in these countries are well documented (e.g., Pichette and Tremblay 2003, Muellbauer and Murphy 2008). An increase in consumption of slightly below 0.10% is associated with a one per cent increase in real house prices. Conversely, the increase in private consumption is initially insignificant in the US and then turns negative after about 2 years. This result seems at odds with the extensive evidence of the impact of housing wealth on consumption in the US (CBO 2007). However, the small impact of the housing demand shock on house prices, which only increase by 0.3%, justifies a limited impact on consumption. Qualitatively similar results have been obtained by Musso *et al.* (2011). The temporary nature of the shock in our model also explains the muted consumption response when compared to estimates involving permanent shocks, as consumption is mostly expected to react to permanent changes in wealth.

Regarding countries with less developed mortgage markets, an insignificant initial response followed by a contraction as inflation and interest rates rise in Italy looks plausible. In France, the consumption response is positive, but insignificant. In Germany, the house price shock has almost no impact on consumption, which is consistent with the low proportion of home-owners and the limited use of housing collateral to secure borrowing to finance consumption. Spain is the only euro area country in the sample where house prices are found to have a positive impact on consumption. Catte *et al.* (2004) find a stronger housing wealth effect on consumption in Spain than in the three largest euro area countries. Furthermore, the heavy weight of construction in the Spanish economy over the sample period is likely to have generated large multiplier effects. In Japan, there is a short-lived initial increase in consumption. As the response of mortgage loans is negative, the increase in consumption is unlikely to be associated with a collateral effect.[15] Furthermore, a weak response of housing investment rules out a strong income multiplier effect. While a pure wealth effect cannot be ruled out, both consumption and house prices could be lifted by a third factor, for example an increase in financial wealth or future income expectations.

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14 Housing equity withdrawal is new borrowing secured on dwellings that is not invested in the housing market (e.g., not used for house purchase or home improvements), so it represents additional funds available for reinvestment or to finance consumption spending (Bank of England).

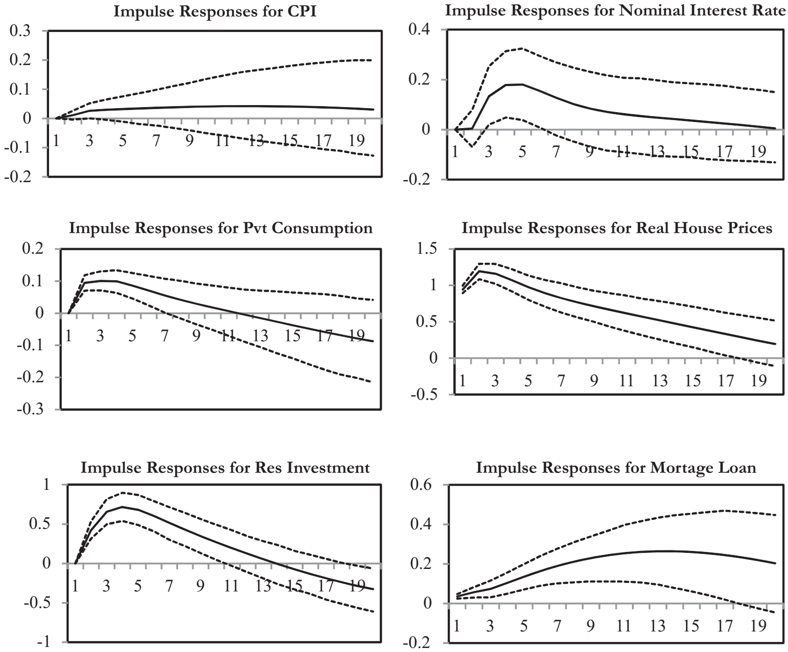
15 Housing wealth could be used as collateral to borrow using non-mortgage instruments. However, this is unlikely, as credit market liberalisation for households has been very limited in Japan (Aron *et al.* 2011).

The demand shock results in a long lasting increase in the level of consumer prices, except in Germany. Two factors are likely to explain such a response. First, part of the increase in consumer prices may result from the inclusion of rents in the CPI. Higher house prices tend to lead to higher rents, as households can to some extent arbitrage between owning and renting their homes. But, as arbitrage is imperfect in housing markets and nominal house prices tend to be sticky on the downside, the adjustment takes place over a protracted period during which rent increases drive the CPI up. Second, the housing demand shock leads to an increase in residential investment and private consumption and hence aggregate demand. Unless there is spare capacity in the economy, higher demand generates inflationary pressures. In Germany, the absence of significant consumption and investment reaction to the shock, as well as a disconnection between the evolutions of rents and prices since the mid-1990s, explains that no inflationary pressures show up.

Monetary authorities might be expected to respond to inflationary tensions by raising their policy rate, to bring inflation back towards their objective. Inflation decelerates, but the level of prices remains permanently above the baseline. The nominal interest rate path, which follows the pattern of the CPI and real variables closely, seems broadly consistent with a reaction by monetary authorities to house prices insofar as they convey information about the future inflation path. In the UK and Japan, the interest rate response leads a significant reaction of the CPI, suggesting that concerns about unsustainable developments in house prices may have played a role in policy decisions. The results are ambiguous for Canada, Spain and the US, where the reactions of the interest rate and the CPI to the the house price shock become statistically significant simultaneously[16]. The interest rate response lags significant increases in the CPI in France and Italy and is insignificant in Germany[17].

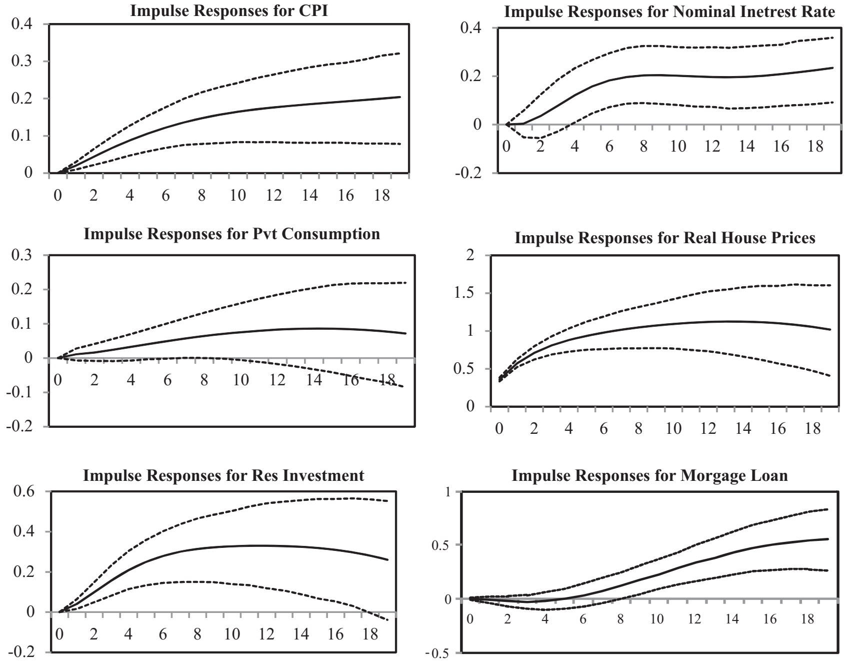
16 Under the Choleski decomposition, the interest rate and the CPI are ordered before the house price, restricting the response of these variables to be delayed by one quarter following a housing demand shock. Hence, in the case where both the response of the interest rate and the CPI are statistically significant after one quarter, it is not possible to infer whether the interest rate responds to the change in real house prices in the previous quarter or to the contemporaneous change in the CPI. This restriction will be lifted in the case agnostic identification procedure.

17 We carried out robustness checks of the results based on the Choleski decomposition, by including two dummies characterizing the European integration (dummy taking a value of 1 from 1999:Q1) and the financial crisis (dummy taking a value of 1 from 2007:Q1) for France, Germany, Italy and, Spain and one dummy capturing the financial crisis (dummy taking a value of 1 from 2007:Q1) for Canada, Japan, the UK and, the US. The results were qualitatively similar to those obtained without the dummies. The details of these results are available upon request from the authors.



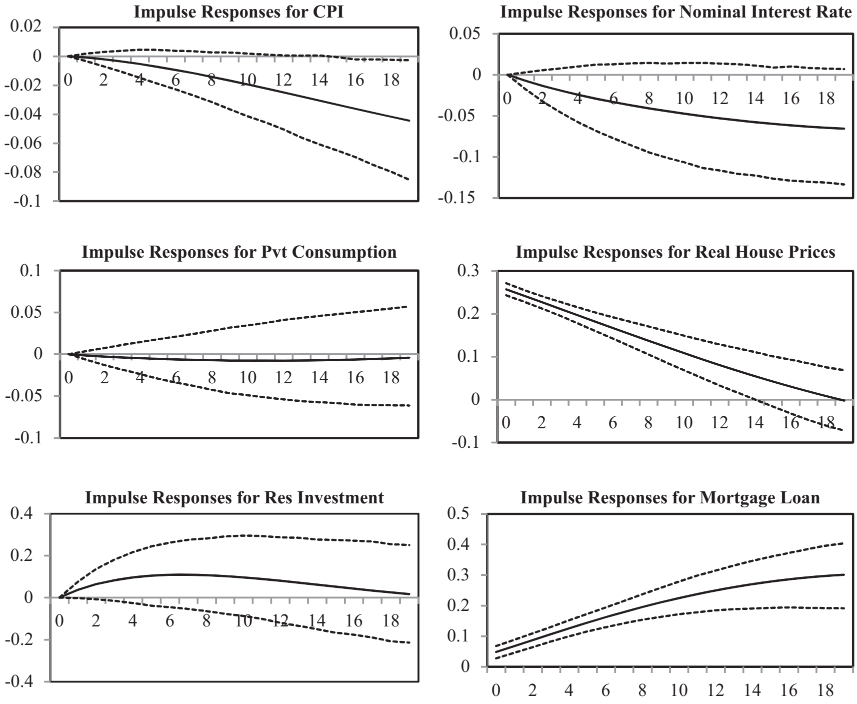

*Note:* The variables are ordered as follows: consumer price index (CPI), private consumption (Pvt. consumption), residential investment (Res. Investment), nominal interest rate, real house price and mortgage loans.

Figure 1: Canada: Choleski (Recursive) Identification Scheme Results: (1970:01 – 2011:04)



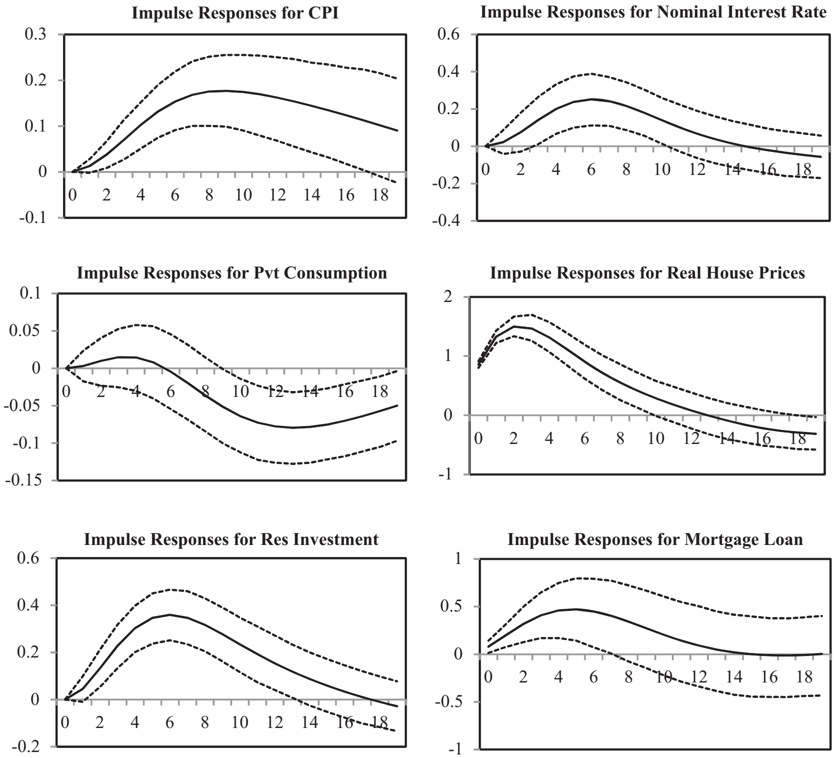

*Note:* See note to Figure 1.

Figure 2: France: Choleski (Recursive) Identification Scheme Results: (1978:01 – 2010:04)



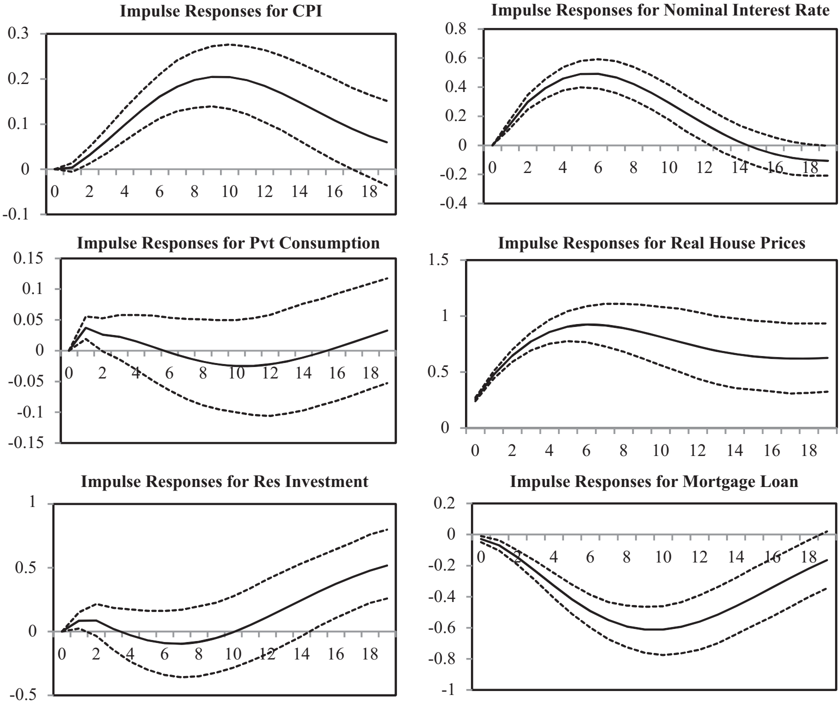

*Note:* See note to Figure 1.

Figure 3: Germany: Choleski (Recursive) Identification Scheme Results: (1970:01 – 2011:04)



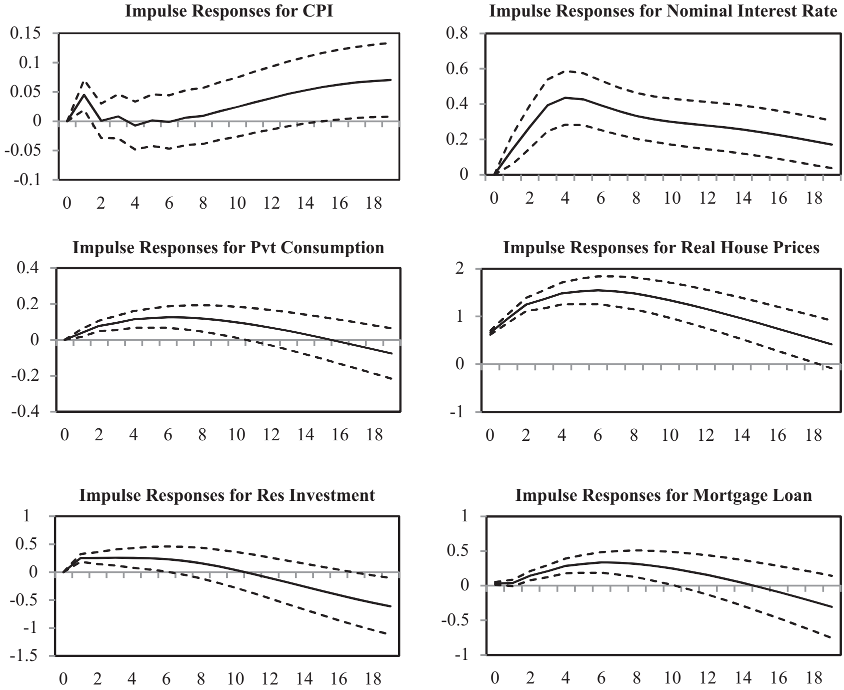

*Note:* See note to Figure 1.

Figure 4: Italy: Choleski (Recursive) Identification Scheme Results: (1975:01 – 2010:04)



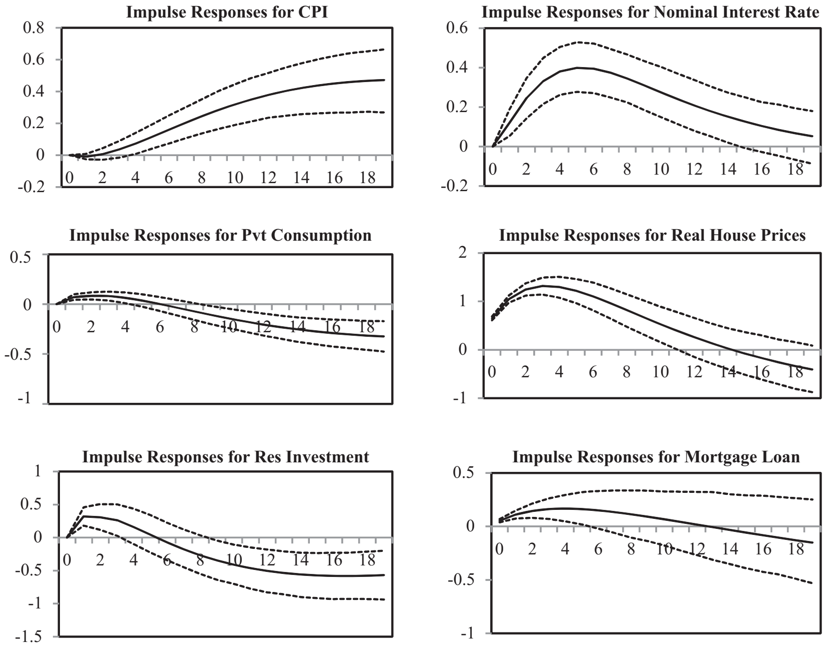

*Note:* See note to Figure 1.

Figure 5: Japan: Choleski (Recursive) Identification Scheme Results: (1970:01 – 2010:04)



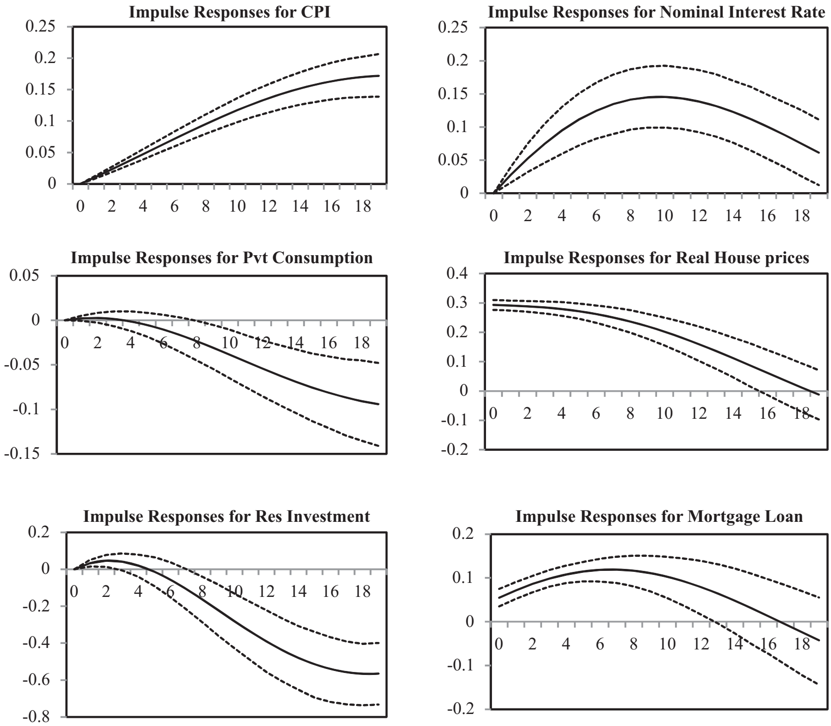

*Note:* See note to Figure 1.

Figure 6: Spain: Choleski (Recursive) Identification Scheme Results: (1980:01 – 2011:04)




*Note:* See note to Figure 1.

Figure 7: UK: Choleski (Recursive) Identification Scheme Results: (1970:01 – 2011:04)




*Note:* See note to Figure 1.

Figure 8: US: Choleski (Recursive) Identification Scheme Results: (1970:01 – 2011:04)

### *3.2.2 Impulse Responses using an Agnostic Identification Procedure*

The recursive identification procedure yields theoretically inconsistent behaviour of the impulse response functions in some cases. Specifically, the insignificant or negative initial response of mortgage loans in France and Japan is incompatible with a housing demand shock. Another advantage of the agnostic identification procedure is that it allows a housing demand shock to be identified without restricting the interest rate response to be delayed, which is essential for the analysis of the monetary policy reaction. Hence, we have used an agnostic identification procedure to better identify a housing demand shock, imposing sign restrictions on all variables except private consumption and nominal interest rates. After a housing demand shock, house prices remain higher than their baseline for a period of about 4 to 5 years (Figures 9 to 16). An exception is Japan, where the impact of the shock has almost disappeared after 2 years. Depending on the country, the deviation from the baseline is statistically significant (at the 68% confidence level) for 6 to 20 quarters. The peak impact ranges from about 0.2% in Germany and the United States to close to 1% in the UK. The initial mortgage loan response is significant in all countries, which is a necessary condition to identify a housing demand shock, as most house purchases are financed with a mortgage. As for house prices, the impact on mortgage lending is long lasting, being significant for 4 quarters in Germany and longer in other countries. Its magnitude is highest in Italy and the United Kingdom.

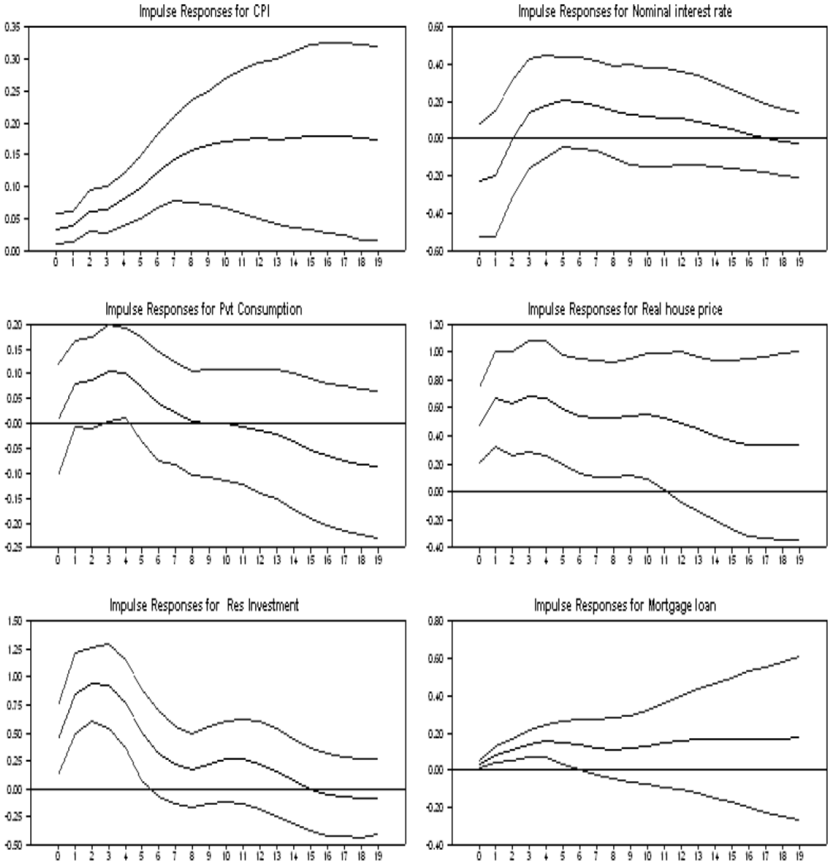
Residential investment responds significantly in all countries, over periods varying from 5 quarters in Canada and the United States to 13 quarters in Spain. The magnitude of the response differs between countries, with the peak impact ranging from less than 0.3% in France and Italy to 0.6% in Spain and around 1% in other countries. In France, the house price shock is fairly small and house prices reach their peak level after a significant delay. The response of housing investment is of the same magnitude as that of house prices. In Italy, the reaction of investment appears small, but consistent with low supply elasticity estimates reported in Caldera Sánchez and Johansson (2011). In Canada and the UK, the response of residential investment is of the same order of magnitude as that of house prices. While a strong responsiveness of housing supply was expected in Canada, it might look more surprising for the UK where land-use planning regulations constrain construction heavily. However, UK housing supply was more responsive in earlier decades than it is now. Furthermore, while the response of supply to house prices is limited during expansions, it remains strong during recessions, as evidenced by the fall of about 40% in investment following the latest financial crisis. In Germany, Japan and the United States, the impact of the shock is much stronger on investment than on prices. This may be linked to the fact that the housing market history of these countries is dominated by one large construction boom, in the late 1980s in Japan, after reunification in Germany and in the 2000s in the United States. During these booms, increases in residential investment have been even more spectacular than price upsurges.

Private consumption shows a significant positive response to the housing demand shock in Canada, France, Japan, Spain and, the UK. The impact comes with a lag, which allows differentiating the housing demand shock from a confidence shock which would contemporaneously increase housing demand and private consumption. The response becomes significant after one quarter in France, Spain and, the UK and three in Canada and, Japan. It remains significant until the fourth quarter in Canada and the sixth in Japan and, the UK. In Spain and, France, the rise in consumption remains significant until respectively the tenth and fourteenth quarter. The results for Canada and, the UK are broadly in line with expectations. The implied elasticities of consumption to house prices are somewhat higher than those of the model with recursive identification and conventional estimates of housing wealth effects. As the house price shock generates income multiplier effects of residential investment in addition to wealth effects, a somewhat higher response than implied by wealth effects alone is not surprising. The response of consumption is fairly strong in Spain. As noted in Section 3.2.1, this is likely to result from a moderate wealth effect combined with large multiplier effects associated with the high share of construction in the Spanish economy.

For Japan and France, the literature suggests that housing wealth effects are, at most, modest. For example, Catte *et al.* (2004) report a long-term elasticity of consumption to housing wealth of 0.06 for Japan and insignificant for France. Chauvin and Damette (2010) estimate an elasticity of 0.08 for France. The consumption response peaks at around 0.10% in France and Japan for a house price increase of 0.25 to 0.3%. In Japan, a strong investment response implies multiplier effects, but given the relatively small share of residential investment in GDP (around 5% over the sample), these cannot alone explain the rise in consumption. This is even more the case in France, where the investment response is small. Hence, it is likely that in these countries, the housing demand shock is associated with other positive shocks on consumption. The asset price boom in Japan in the late 1980s, with strong increases in equity values coinciding with soaring house prices, could be part of the explanation for the Japanese results. In France, such a single event that could drive the results cannot be identified. Nevertheless, while the median consumption response for France and Japan looks strong, a plausible response would still lie between the 68% confidence bands. In the three remaining countries, the consumption response is insignificant, which as discussed earlier was expected in Germany and, Italy, but less so in the US.

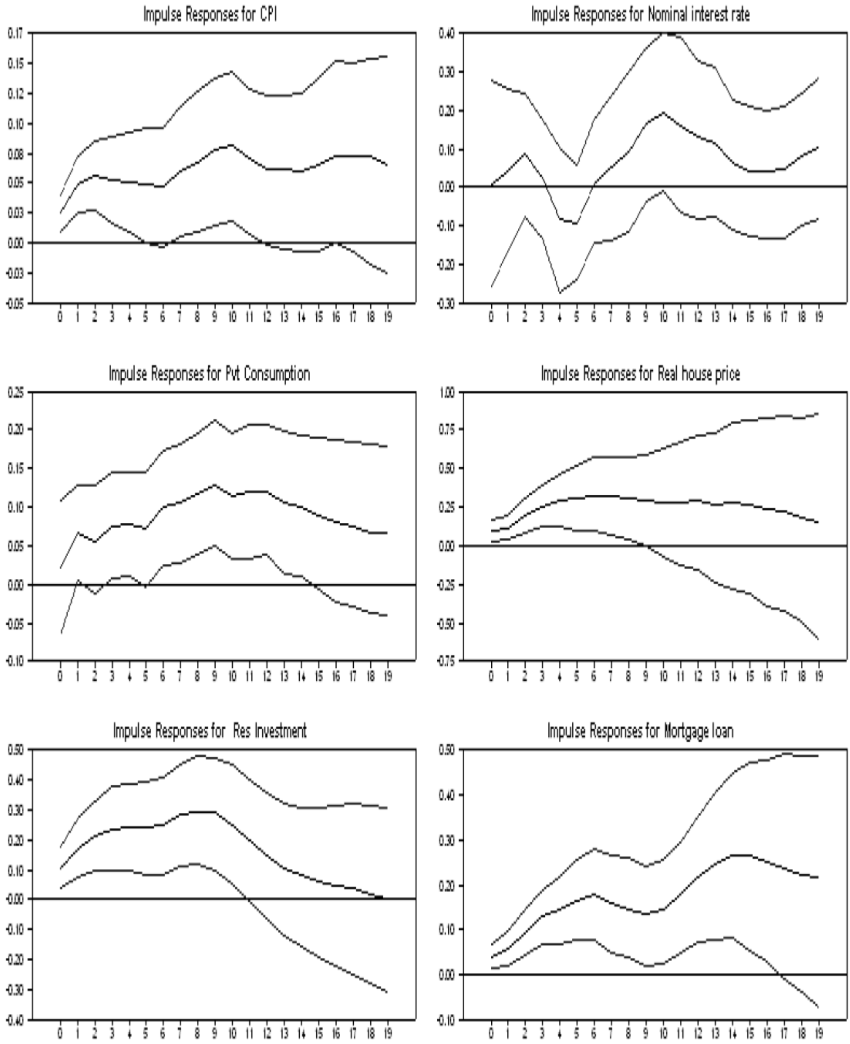
Consumer prices react positively to the house price shock in all countries. The response remains statistically significant for more than five years in all countries except France and, Italy, where it becomes insignificant after respectively 12 and 9 quarters. As noted earlier, the slow adjustment of the price-to-rent ratio to its equilibrium level through rent increases rationalises a permanent shift in the level of consumer prices, while a transitory inflationary effect associated with the increase in aggregate demand fades as residential investment and private consumption return towards their baseline level. The inflationary effect of the house price shock is moderate, at most about 0.2%, taking into account the monetary policy response. The latter varies across countries. It is statistically significant in four countries. The response is delayed, becoming statistically significant after 2 quarters in Germany and the UK, 4 quarters in Japan and 6 quarters in the US. The delay and the fact that the interest rate reaction lags a significant CPI response suggest that while monetary authorities in these countries respond to economic developments initiated by the house price shock, they do not directly react to house prices, although they could be part of a set of indicators justifying "leaning against the wind" policies. [18] In Canada, France, Spain and Italy, the interest rate response is insignificant.

[18] Contrary to the Choleski identification scheme, the sign-restriction approach allows the interest rate to move contemporaneously following a house price shock. Hence, it is possible to assess whether the central bank responds immediately to the house price shock and whether this response is statistically significant before the house price shock has led to a significant increase in the CPI.



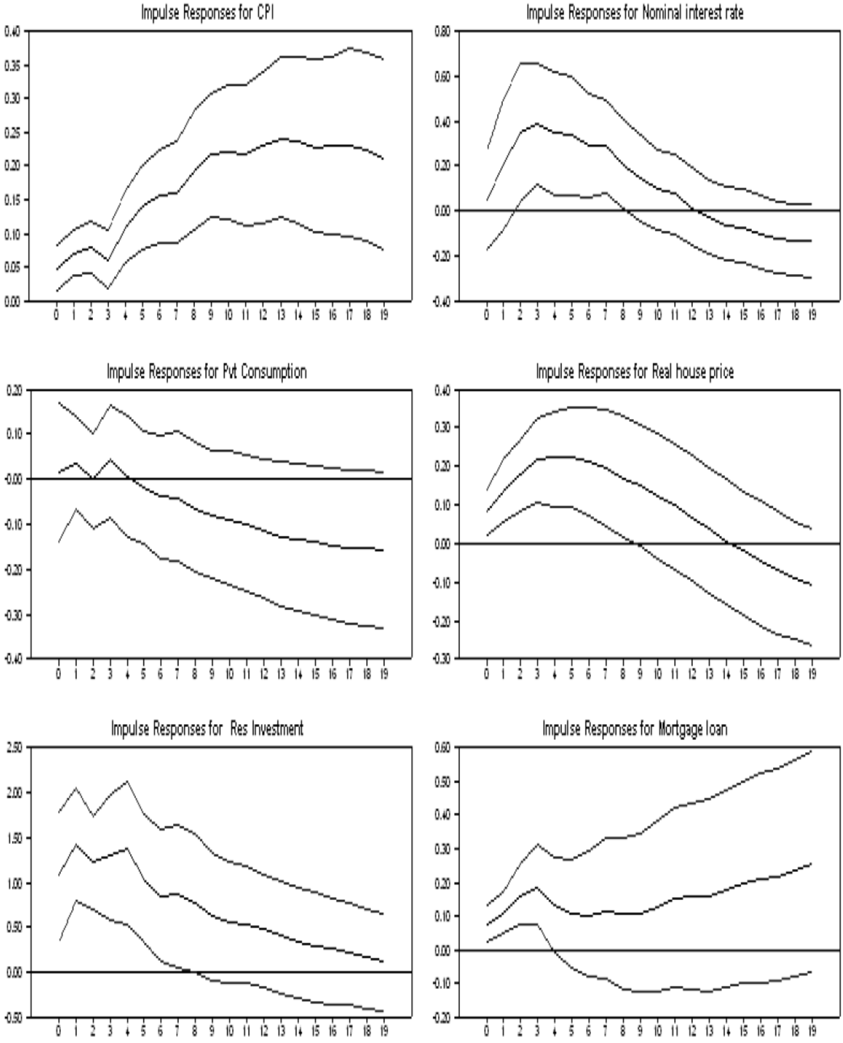

*Note:* Restrictions on Real House Price, CPI, Res investment and Mortgage loan hold for four quarters.

Figure 9: Canada: Impulse Responses with Sign Restrictions: (1970:01 – 2011:04)



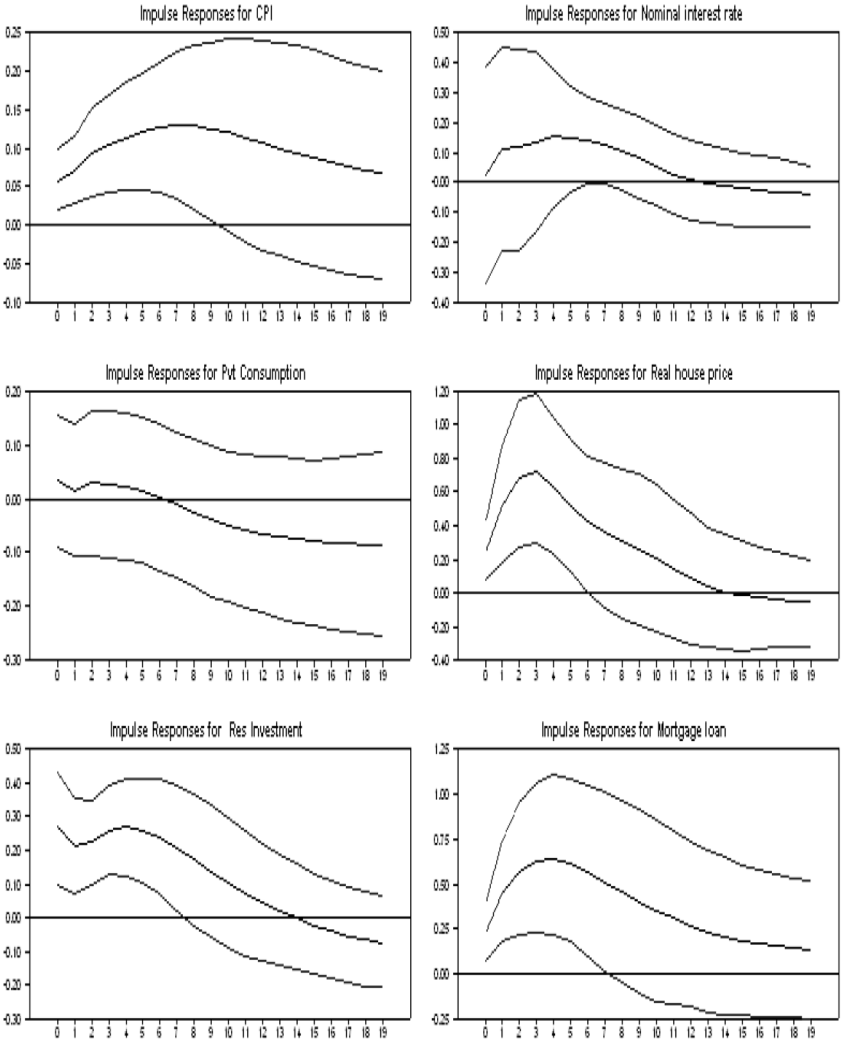

*Note:* See note to Figure 9.

Figure 10: France: Impulse Responses with Sign Restrictions: (1978:01 – 2010:04)



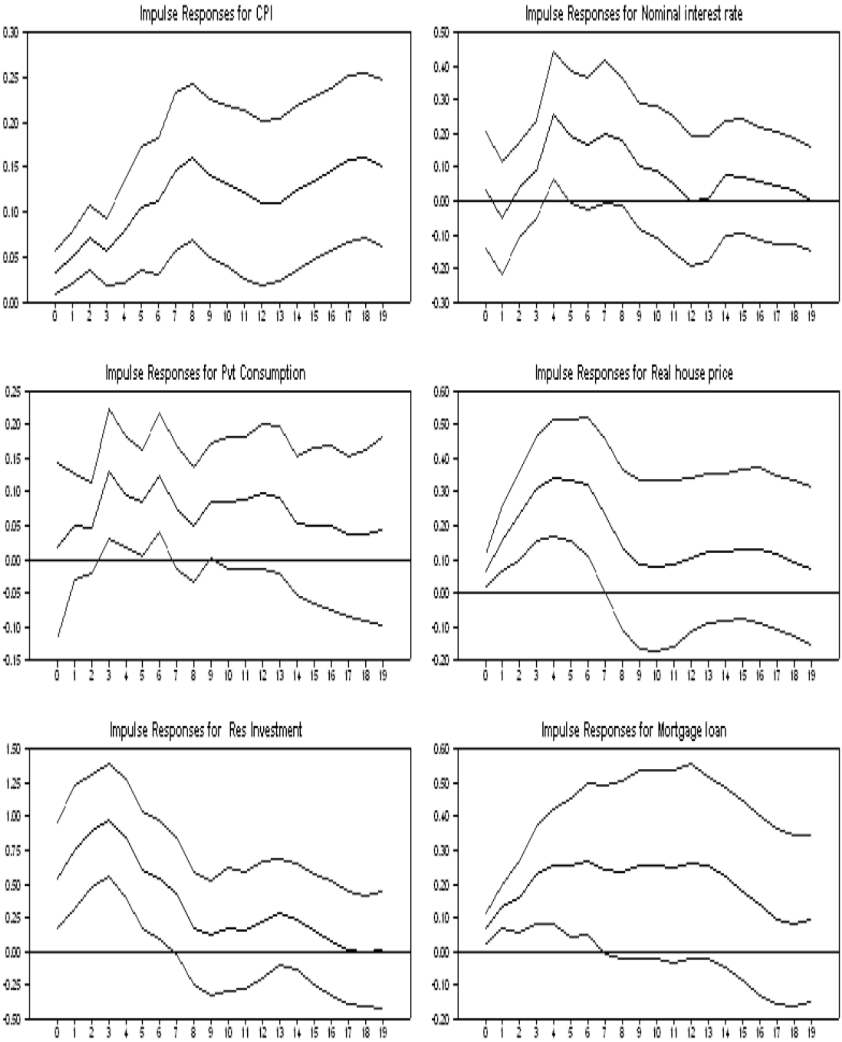

*Note:* See note to Figure 9.

Figure 11: Germany: Impulse Responses with Sign Restrictions: (1970:01 – 2011:04)



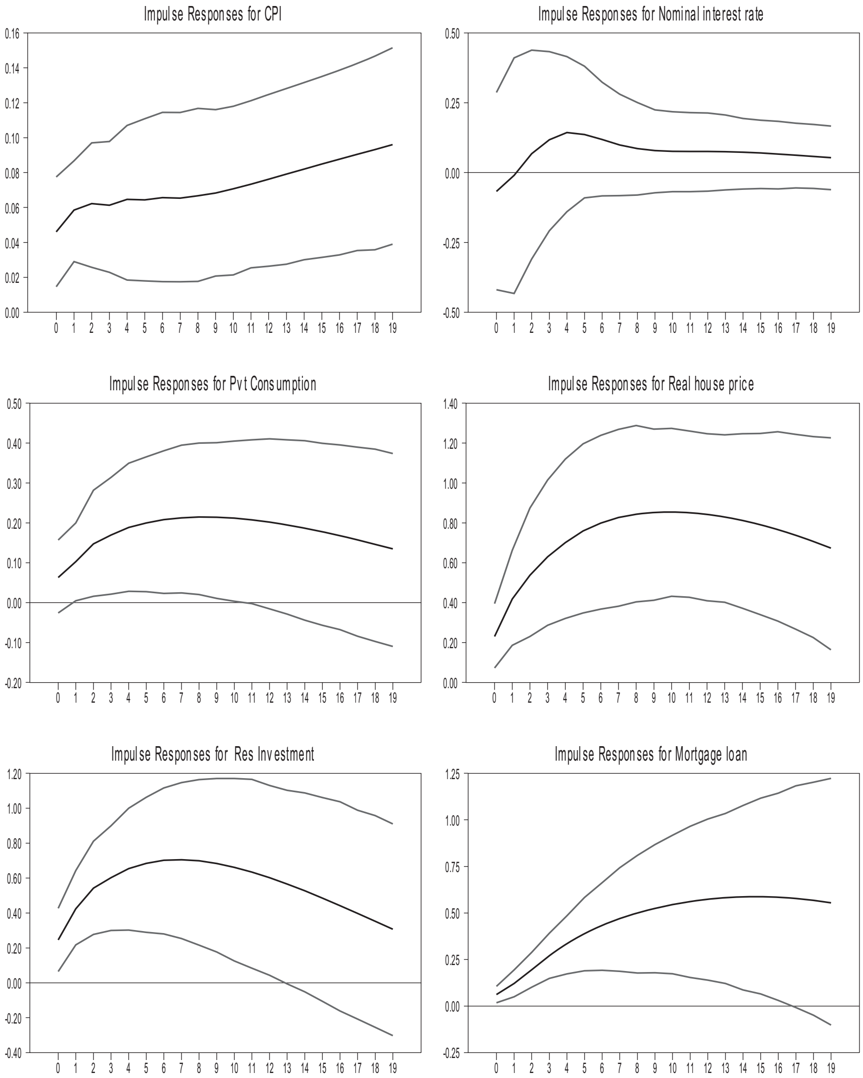

*Note:* See note to Figure 9.

Figure 12: Italy: Impulse Responses with Sign Restrictions: (1975:01 – 2010:04)



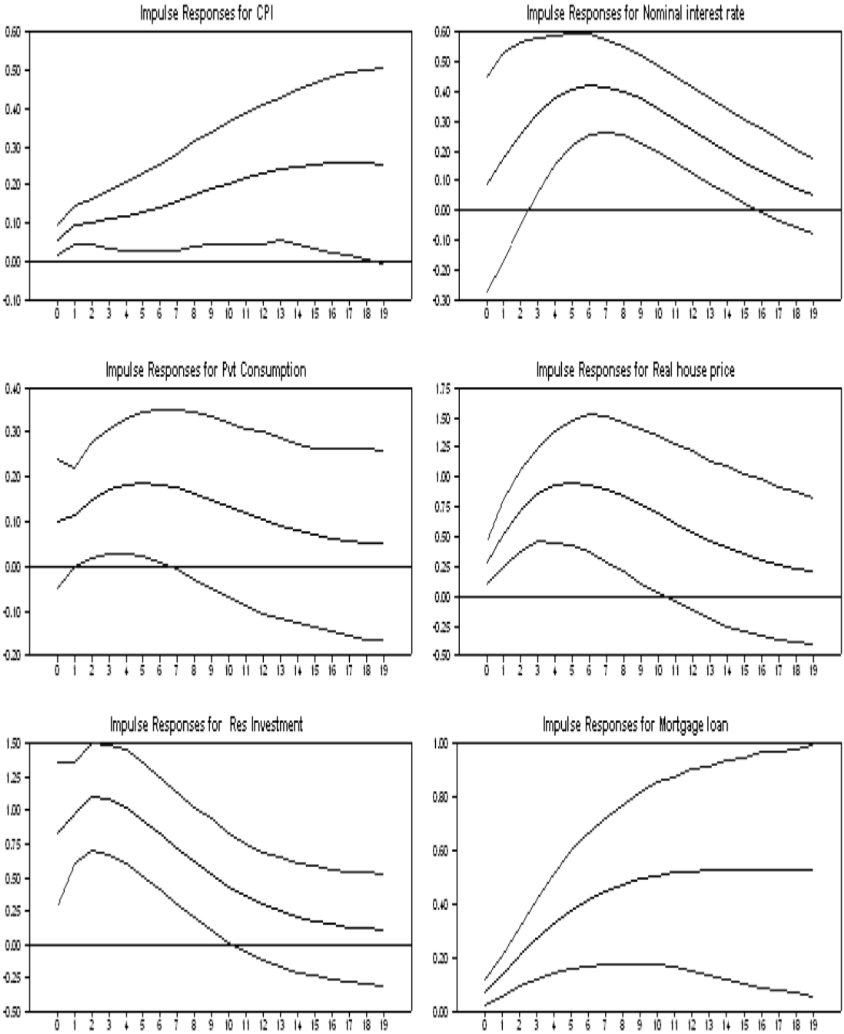

*Note:* See note to Figure 9.

Figure 13: Japan: Impulse Responses with Sign Restrictions: (1970:01 – 2010:04)



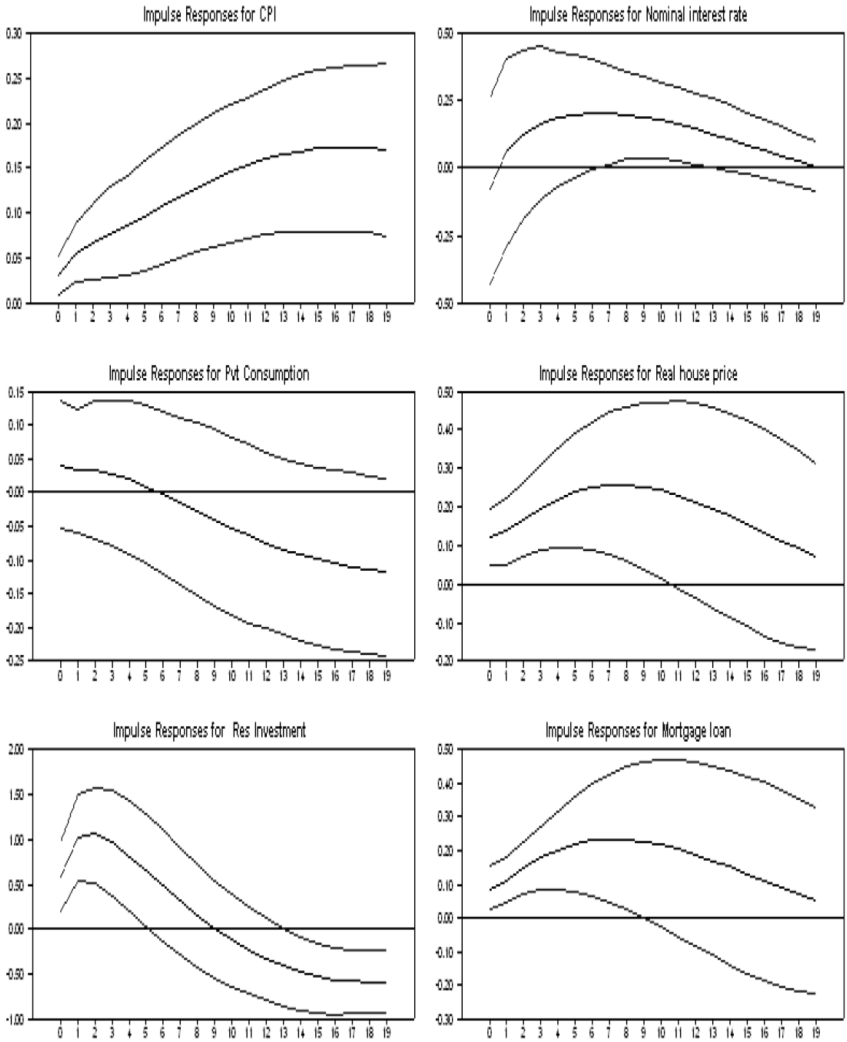

*Note:* See note to Figure 9.

Figure 14: Spain: Impulse Responses with Sign Restrictions: (1980:01 – 2011:04)




*Note:* See note to Figure 9.

Figure 15: UK: Impulse Responses with Sign Restrictions: (1970:01 – 2011:04)




*Note:* See note to Figure 9.

Figure 16: US: Impulse Responses with Sign Restrictions: (1970:01 – 2011:04)

### *3.2.3 Variance Decomposition (Nominal Interest Rate and Private Consumption)*

The variance decomposition allows the importance of the housing demand shock in explaining fluctuations in the variables of the model to be assessed (Figures 17 to 24 in the Appendix). It is most relevant for the variables which have been kept unrestricted. The proportion of private consumption and nominal interest rate variance explained by the house price shock is remarkably similar across countries. The shock accounts for variations in both variables of 10 to 15% after five years. These results are of similar magnitude as those reported by other researchers for the US and the euro area. Musso *et al.* (2011) find that housing demand shocks explain 11% of consumption variance at the 24 quarter horizon in the US and 10% in the euro area. They also find that a house price shock explains about 10% of short-term interest rate variations in the US and 15% in the euro area. Jarocinski and Smets (2008) find results that are somewhat lower for consumption and higher for interest rates. In their difference VAR, a housing demand shock explains about 5% of US consumption variance and in their level VAR, slightly over 9%. The share of interest rate variance attributable to the housing demand shock is respectively about 18% and 21% in the difference and level VARs. Overall, our study largely confirms the results reported by the sources cited for the US and the Euro area and extends them to eight OECD countries, where housing demand shocks appear to have a broadly similar role in explaining consumption and interest rate volatility.

## 4. Conclusion

A six-variable VAR model including house prices, consumer prices, residential investment, mortgage loans, private consumption and nominal interest rates provides a plausible description of the behaviour of eight OECD economies following a house price shock. While Choleski's recursive identification scheme generally yields theoretically consistent impulse responses, it is not the case for all countries. Following Uhlig's (2005) agnostic identification procedure, imposing sign restrictions on the responses of real house prices, consumer prices, residential investment and mortgage loans allows the identification of housing demand shocks that are in line with theoretical priors for all countries. Hence, the framework is adequate to investigate the behaviour of private consumption and nominal interest rates, variables which are left unrestricted, following a housing demand shock. Evidence of significant and positive spillovers from the housing sector to private consumption is found for Canada, France, Japan, Spain and, the UK. Central banks do not seem to respond instantly and systematically to a housing demand shock, but movements in house prices have a delayed positive impact on nominal interest rates after a few quarters in Germany, Japan, the UK and, the US, suggesting that spillovers onto the wider economy tend to trigger a monetary policy response. These results are broadly in line with the findings of the SVAR literature, which they extend to a wider set of countries. They are also broadly consistent with the literature on housing wealth effects on consumption. House price shocks play a significant role in economic fluctuations. They tend to trigger delayed policy rate adjustments, as they spill over to the wider economy. At a time when central banks around the world are strenghtening their macro-prudential frameworks, it is useful to recall that house price developments can provide useful and timely information to policymakers.

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## Appendix

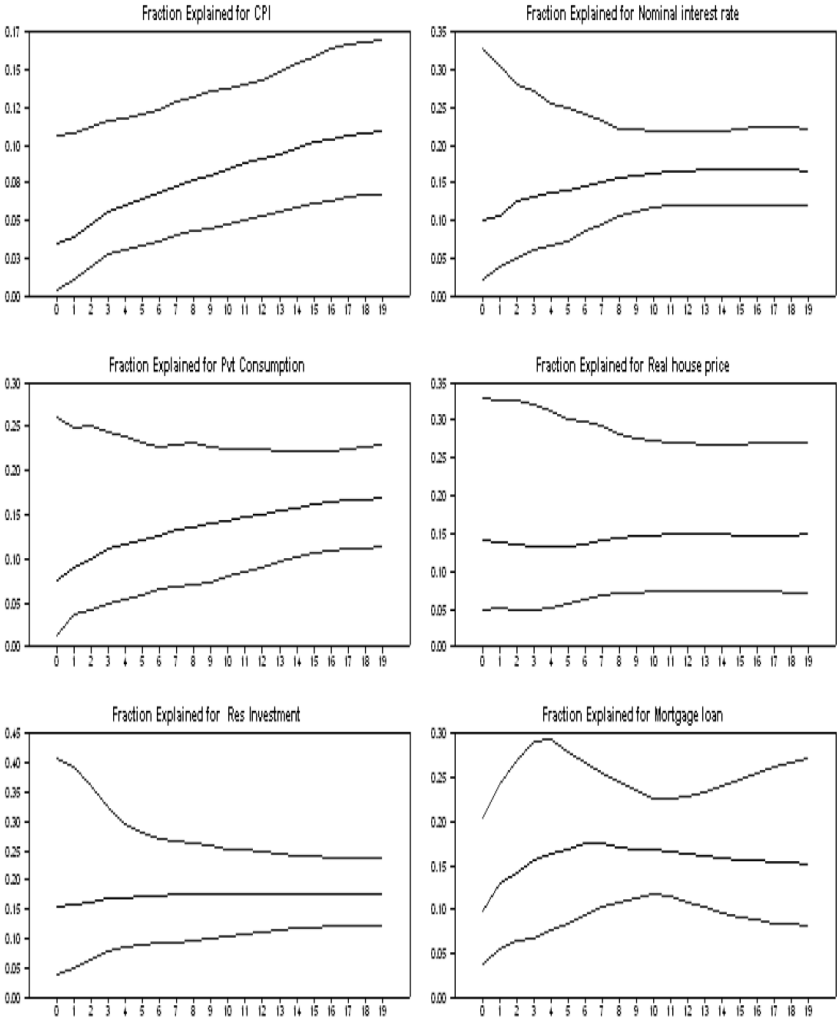



Figure 17: Canada: Fraction of Variance Explained with Pure-Sign Approach

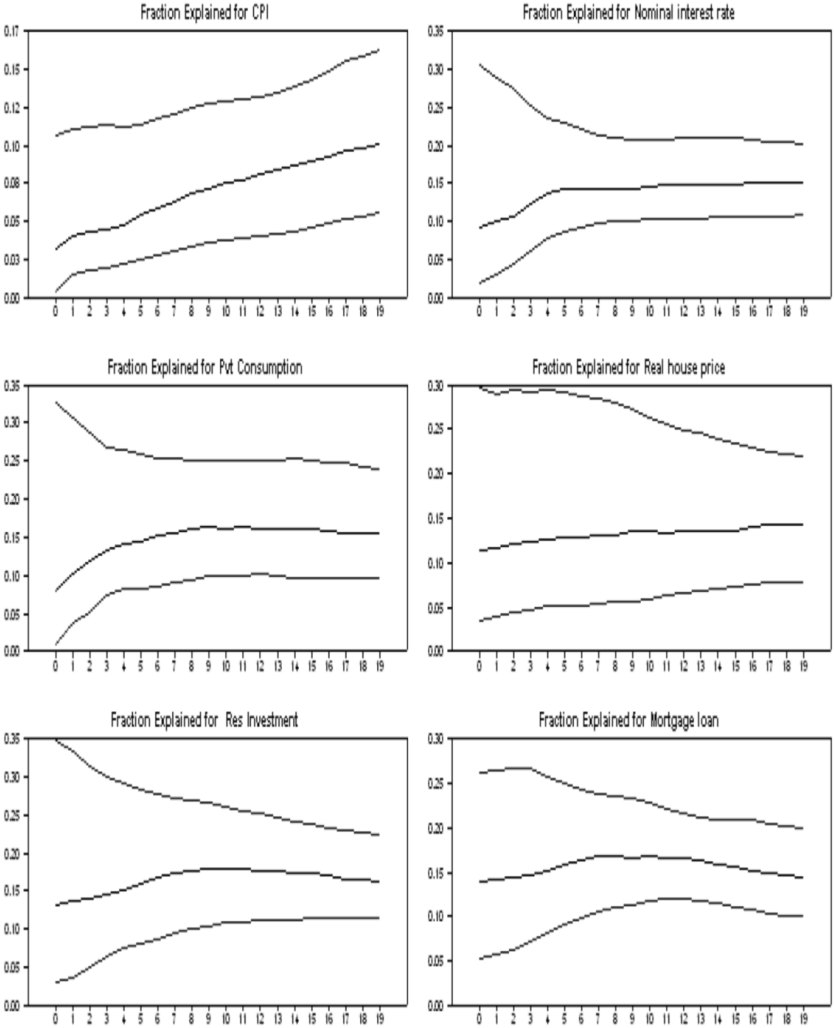



Figure 18: France: Fraction of Variance Explained with Pure-Sign Approach

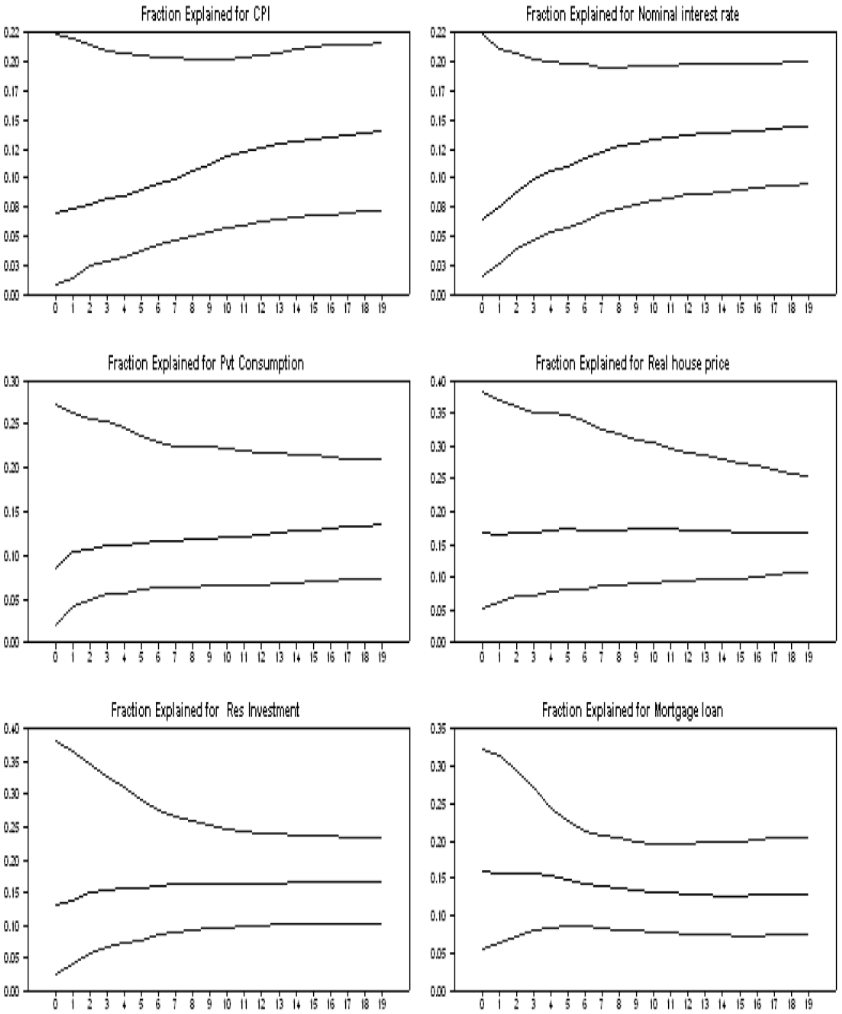



Figure 19: Germany: Fraction of Variance Explained with Pure-Sign Approach

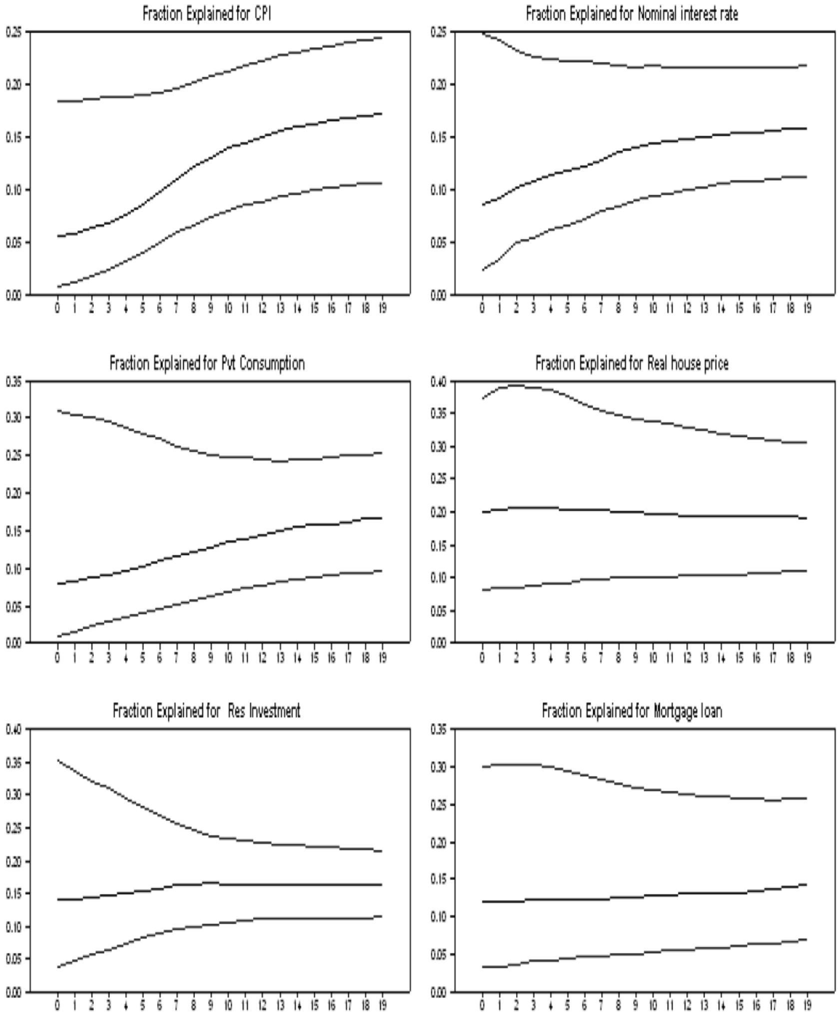



Figure 20: Italy: Fraction of Variance Explained with Pure-Sign Approach

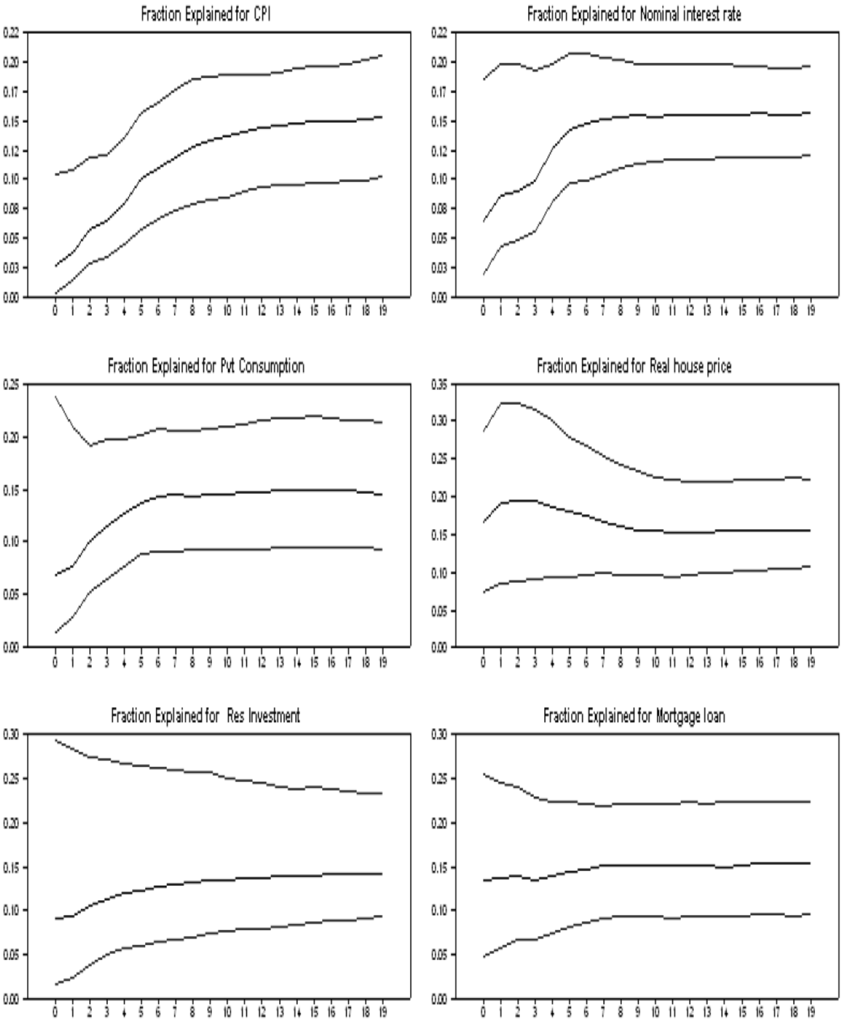



Figure 21: Japan: Fraction of Variance Explained with Pure-Sign Approach

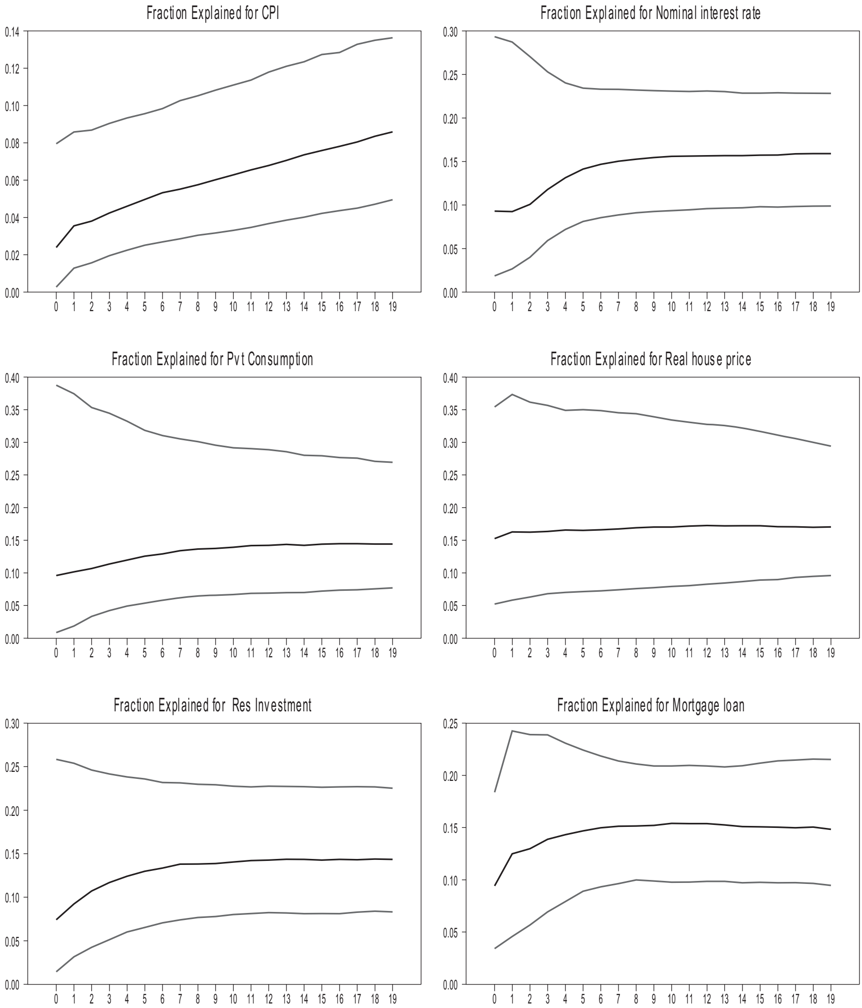



Figure 22: Spain: Fraction of Variance Explained with Pure-Sign Approach

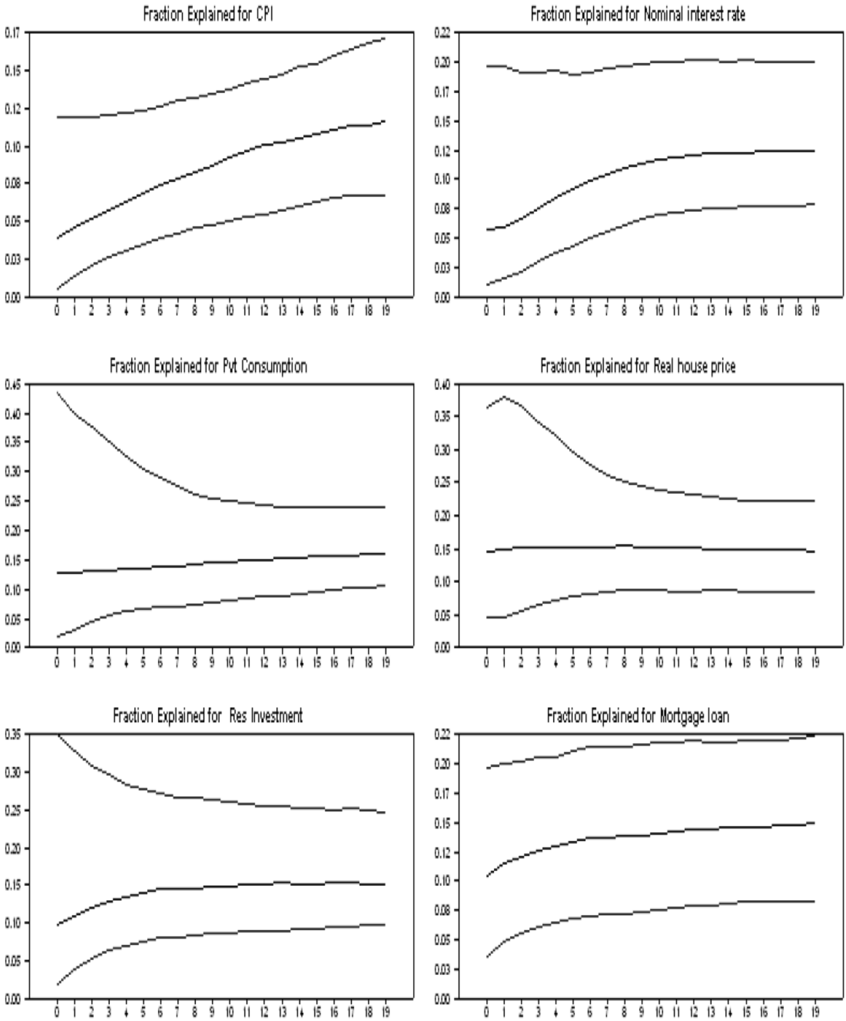



Figure 23: United Kingdom: Fraction of Variance Explained with Pure-Sign Approach

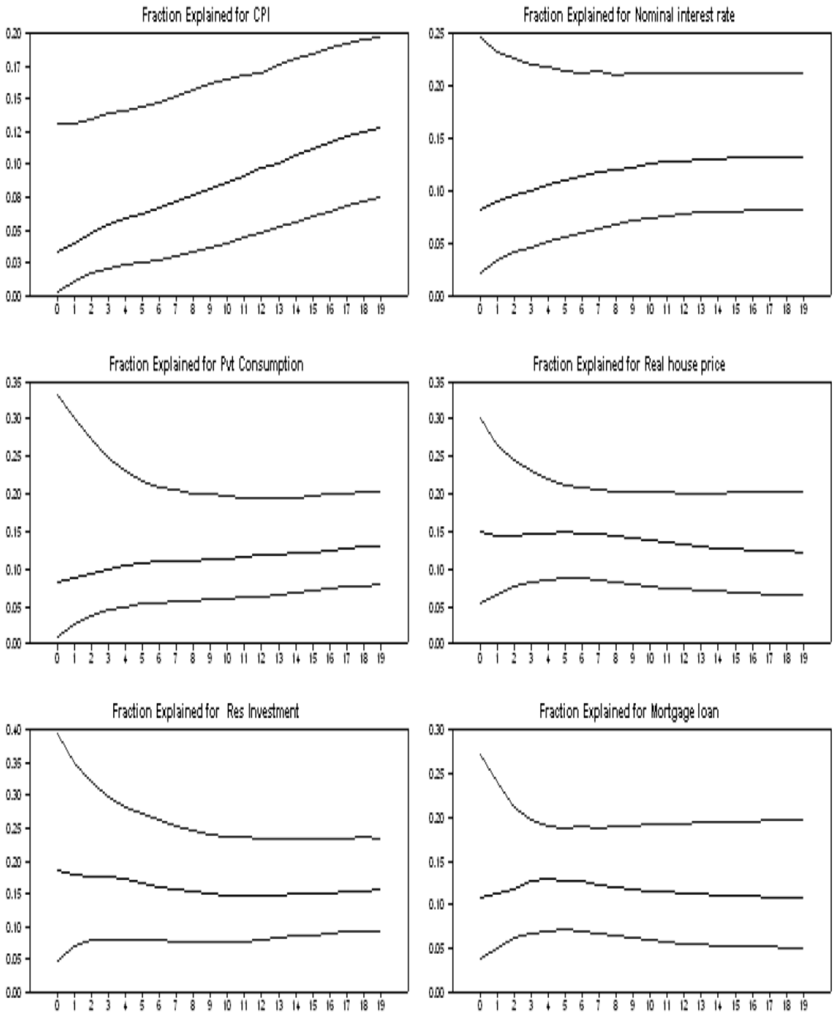


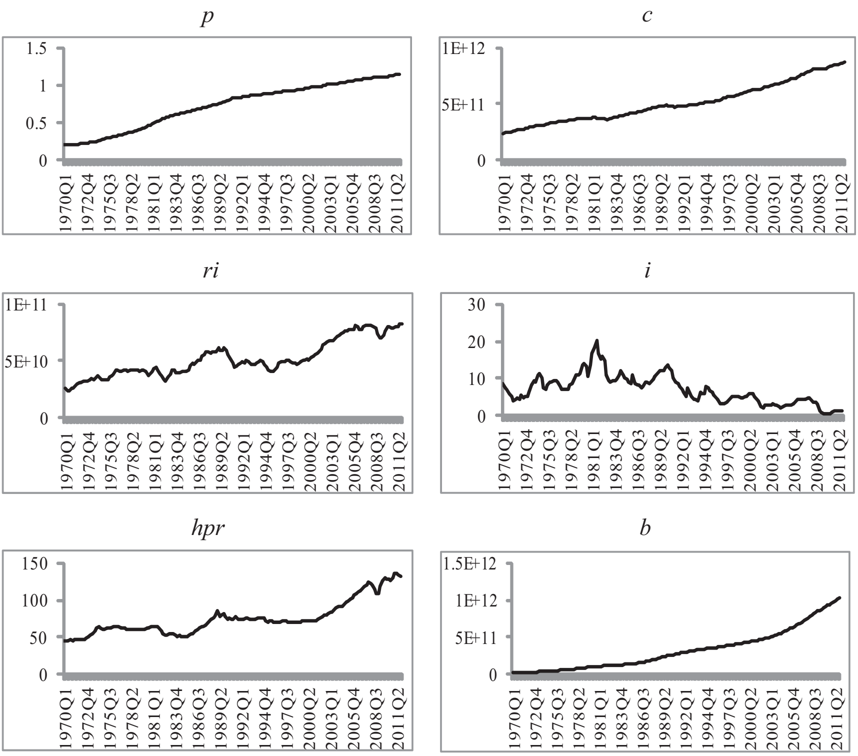

Figure 24: United States: Fraction of Variance Explained with Pure-Sign Approach

*Table A1*

**Descriptive Statistics of the Untransformed Variables used in the Estimation of the VARs**

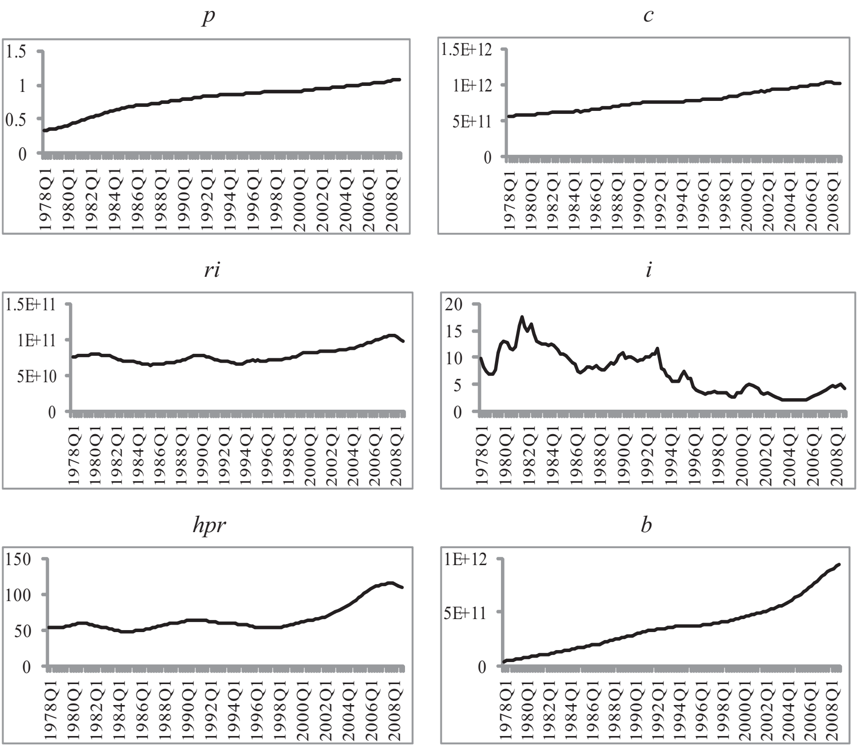
| Countries | | p | c | ri | i | hpr | b |
|---|---|---|---|---|---|---|---|
| | Mean | 0.7279 | 5.08E+11 | 5.17E+10 | 6.9509 | 74.8930 | 3.22E+11 |
| | SD | 0.2988 | 1.73E+11 | 1.57E+10 | 3.9124 | 22.5578 | 2.67E+11 |
| **Canada (1970:1–2011:4)** | Min | 0.2041 | 2.41E+11 | 2.31E+10 | 0.4250 | 44.7542 | 2.32E+10 |
| **N=168** | Max | 1.1484 | 8.67E+11 | 8.3E+10 | 20.3789 | 135.8237 | 1.03E+12 |
| | Mean | 0.7908 | 7.78E+11 | 7.82E+10 | 7.1921 | 66.1631 | 3.7E+11 |
| | SD | 0.1951 | 1.39E+11 | 1.05E+10 | 3.8539 | 18.5567 | 2.23E+11 |
| **France (1978:1–2008:4)** | Min | 0.3271 | 5.58E+11 | 6.47E+10 | 2.0630 | 48.7350 | 4.83E+10 |
| **N=124** | Max | 1.0768 | 1.03E+12 | 1.05E+11 | 17.4400 | 115.3950 | 9.42E+11 |
| | Mean | 0.7683 | 1.05E+12 | 1.03E+11 | 5.4194 | 114.2032 | 4.55E+11 |
| | SD | 0.2117 | 2.36E+11 | 2.8E+10 | 2.9180 | 8.5757 | 3.01E+11 |
| **Germany (1970:1–2011:4)** | Min | 0.3541 | 6E+11 | 4.36E+10 | 0.6622 | 96.7284 | 8.25E+10 |
| **N=168** | Max | 1.0934 | 1.36E+12 | 1.48E+11 | 14.3733 | 128.2704 | 9.21E+11 |
| | Mean | 0.6408 | 6.87E+11 | 6.86E+10 | 9.5137 | 80.0312 | 1.57E+11 |
| | SD | 0.3151 | 1.39E+11 | 6.36E+09 | 5.6756 | 14.1566 | 1.68E+11 |
| **Italy (1975:1–2010:4)** | Min | 0.0998 | 4.18E+11 | 6.07E+10 | 0.6622 | 58.8388 | 4.57E+09 |
| **N=144** | Max | 1.1051 | 8.71E+11 | 8.59E+10 | 20.4756 | 107.1493 | 5.45E+11 |
| | Mean | 0.8846 | 2.19E+14 | 1.94E+13 | 4.2128 | 115.9753 | 1.06E+14 |
| | SD | 0.2062 | 6.35E+13 | 3.44E+12 | 3.7083 | 20.4374 | 6.8E+13 |
| **Japan (1970:1–2010:4)** | Min | 0.3463 | 1.01E+14 | 1.17E+13 | 0.0250 | 81.6788 | 2.72E+12 |
| **N=164** | Max | 1.0701 | 3.01E+14 | 2.76E+13 | 17.5167 | 163.2610 | 1.92E+14 |
| | Mean | 0.6520 | 4.4E+11 | 7.29E+10 | 8.5995 | 59.3637 | 2.82E+11 |
| | SD | 0.2474 | 1.14E+11 | 2.75E+10 | 5.8267 | 26.1779 | 2.95E+11 |
| **Spain (1980:1–2011:4)** | Min | 0.2000 | 2.93E+11 | 4.13E+10 | 0.6622 | 24.5145 | 1.9E+10 |
| **N=128** | Max | 1.0577 | 6.37E+11 | 1.3E+11 | 22.7167 | 108.9382 | 8.71E+11 |
| | Mean | 0.6038 | 5.86E+11 | 6.17E+10 | 8.2641 | 54.4465 | 3.95E+11 |
| | SD | 0.3042 | 2.02E+11 | 1.84E+10 | 4.0073 | 26.6460 | 4E+11 |
| **UK (1970:1–2011:4)** | Min | 0.0957 | 3.13E+11 | 1.94E+10 | 0.5894 | 24.1075 | 1.05E+10 |
| **N=168** | Max | 1.1108 | 9.37E+11 | 1.08E+11 | 17.6788 | 113.9516 | 1.25E+12 |
| | Mean | 0.6959 | 5.76E+12 | 4.36E+11 | 6.4784 | 69.9792 | 3.65E+12 |
| | SD | 0.2729 | 2.17E+12 | 1.34E+11 | 3.7607 | 14.2523 | 3.41E+12 |
| **US (1970:1–2011:4)** | Min | 0.2327 | 2.72E+12 | 2.27E+11 | 0.3780 | 49.2178 | 2.87E+11 |
| **N=168** | Max | 1.1465 | 9.48E+12 | 7.83E+11 | 18.3933 | 105.3110 | 1.08E+13 |

*Notes:* consumer price level ($p$), private consumption ($c$), residential investment ($ri$), nominal interest rate ($i$), house price ($hpr$) and real mortgage loans ($b$). N denotes number of observations.



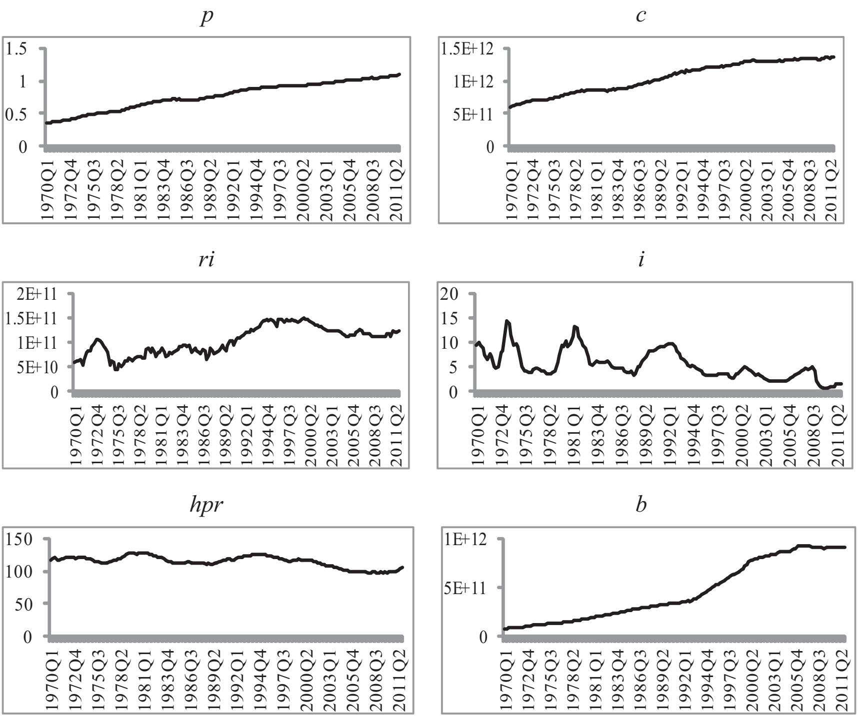

*Notes:* consumer price level (*p*), private consumption (*c*), residential investment (*ri*), nominal interest rate (*i*), house price (*hpr*) and real mortgage loans (*b*).

Figure A1: Plots of Untransformed Variables used in the Estimation of the VAR for Canada (1970:1 – 2011:4)



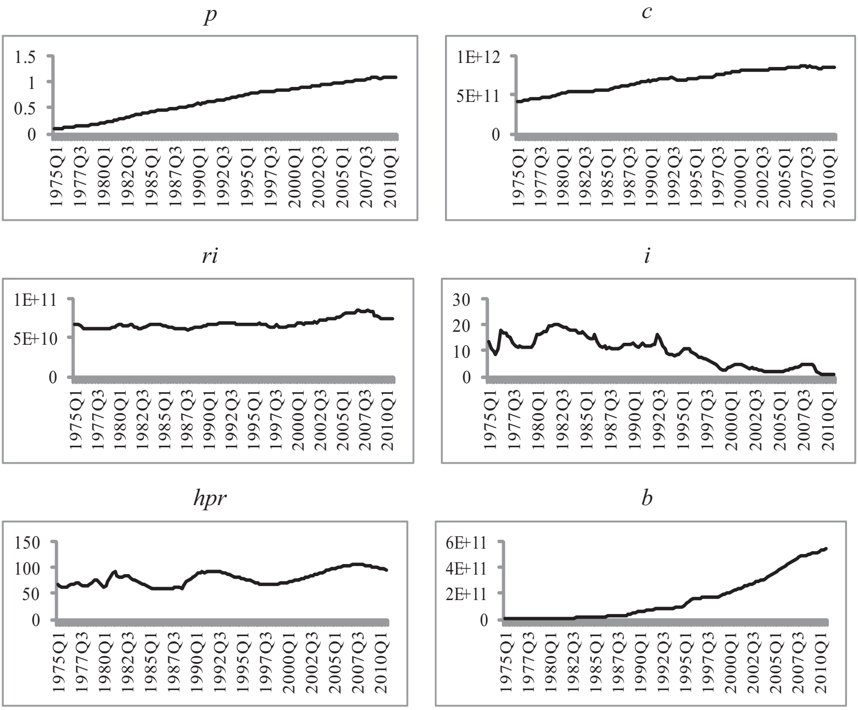

*Notes:* See notes to Figure A1.

Figure A2: Plots of Untransformed Variables used in the Estimation of the VAR for France (1978:1 – 2008:4)



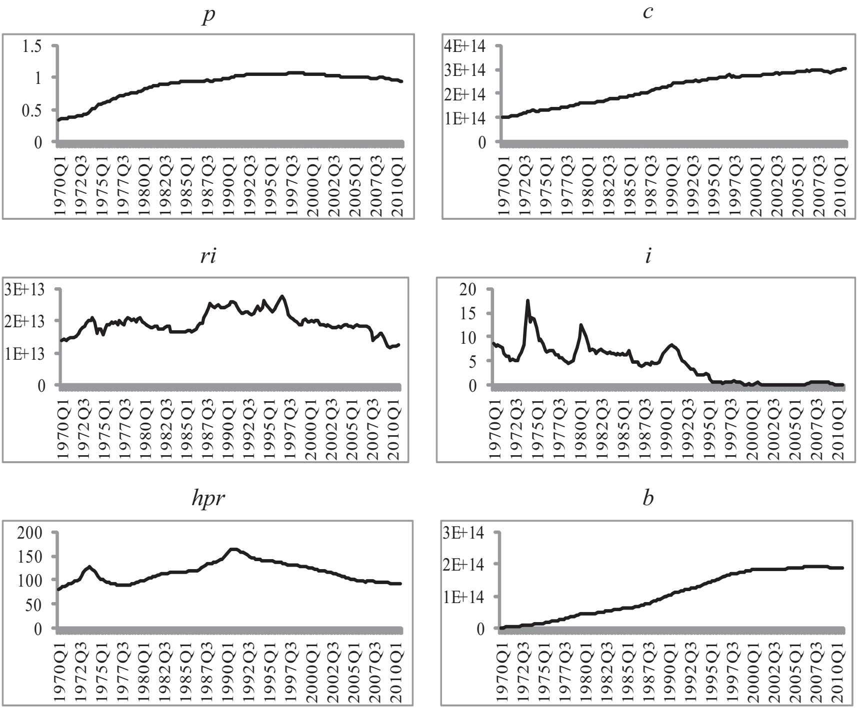

*Notes:* See notes to Figure A1.

Figure A3: Plots of Untransformed Variables used in the Estimation of the VAR for Germany (1970:1 – 2011:4)



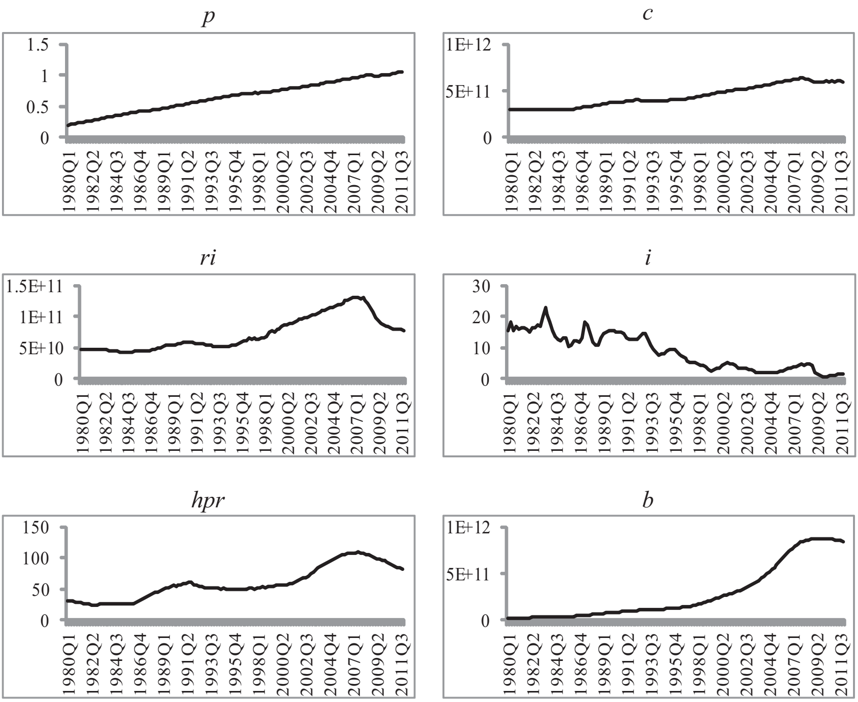

*Notes:* See notes to Figure A1.

Figure A4: Plots of Untransformed Variables used in the Estimation of the VAR for Italy (1975:1 – 2010:4)



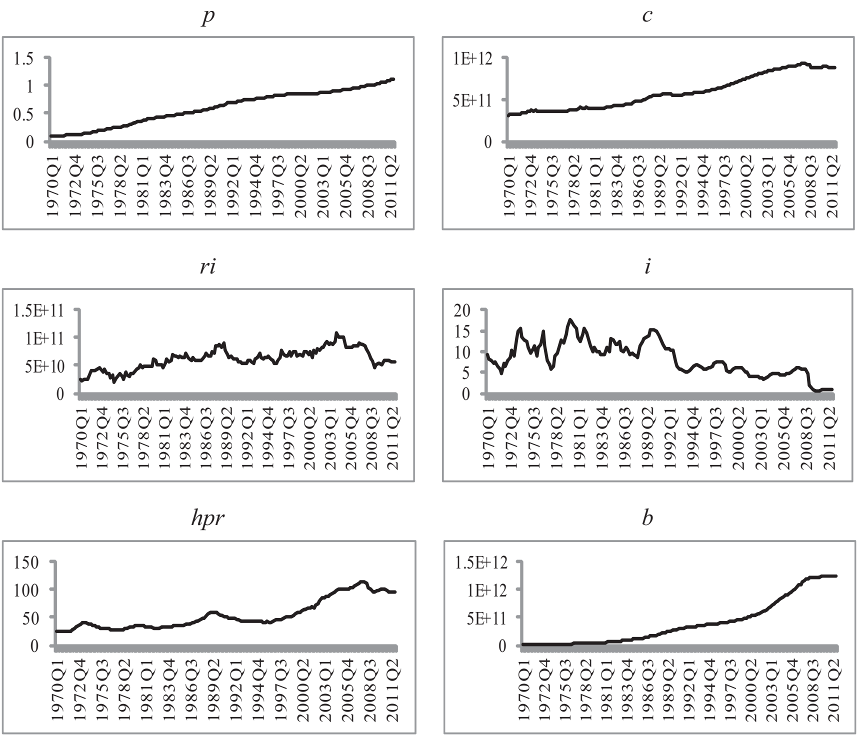

*Notes:* See notes to Figure A1.

Figure A5: Plots of Untransformed Variables used in the Estimation of the VAR for Japan (1970:1 – 2010:4)



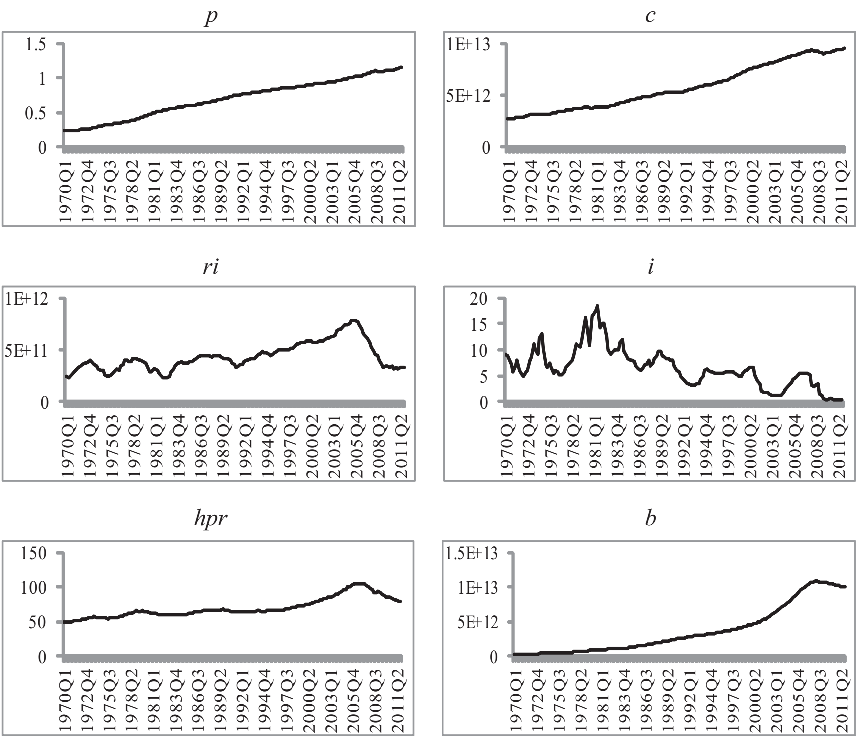

*Notes:* See notes to Figure A1.

Figure A6: Plots of Untransformed Variables used in the Estimation of the VAR for Spain (1980:1 – 2011:4)




*Notes:* See notes to Figure A1.

Figure A7: Plots of Untransformed Variables used in the Estimation of the VAR for UK (1970:1 – 2011:4)




*Notes:* See notes to Figure A1.

Figure A8: Plots of Untransformed Variables used in the Estimation of the VAR for US (1970:1 – 2011:4)