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Do House Prices Impact Consumption and Interest Rate? Evidence from OECD Countries Using an Agnostic Identification Procedure

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DO HOUSE PRICES IMPACT CONSUMPTION AND INTEREST RATE? EVIDENCE FROM OECD COUNTRIES USING AN AGNOSTIC IDENTIFICATION PROCEDURE

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ABSTRACT / RÉSUMÉ

Do house prices impact consumption and interest rate?
Evidence from OECD countries using an agnostic identification procedure

This paper investigates the existence of significant spillovers from the housing sector onto the wider economy for the seven major OECD countries using Uhlig's (2005) agnostic identification procedure. This method allows a housing demand shock to be identified in a six-variable VAR model 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 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, their repercussions on the economy tend to translate into higher policy rates after a few quarters.

Keywords: House Prices, Monetary Policy, Consumption, Agnostic Identification
JEL Classification: *C32; E31; E32; E44; E52*

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Les prix des logements affectent-ils la consommation et le taux d'intérêt ?
Une étude empirique sur des pays de l'OCDE utilisant une procédure d'identification agnostique

Cet article étudie l'existence d'une inflence significative du secteur du logement sur l'économie dans son ensemble pour les sept grands pays de l'OCDE, en utilisant la procédure d'identification agnostique d'Uhlig (2005). Cette méthode permet l'identification d'un choc de demande de logement dans un modèle VAR à six variables en imposant des restrictions sur les signes des fonctions de réaction aux innovations des prix à la consommation, de l'investissement résidentiel, des prix réels des logements et des prêts hypothécaires, tandis que les réponses de la consommation privée et des taux d'intérêt nominaux sont laissées libres. Les résultats suggèrent que la consommation réagit positivement et significativement à un choc de prix des logements au Canada, en France, au Japon et au Royaume-Uni. D'autre part, une réponse positive, significative et retardée des taux d'intérêt nominaux suit un choc de prix des logements en Allemagne, au Japon, au Royaume-Uni et aux Etats-Unis, suggérant que si les banques centrales ne semblent pas réagir instantanément et systématiquement à un choc de demande de logement, les répercussions de ce dernier sur l'économie ont tendance à se traduire par des taux directeurs plus élevés après quelques trimestres.

Mots clés: Prix des logements, Politique monétaire, Consommation, Identification agnostique.
Classification JEL: *C32; E31; E32; E44; E52*

TABLE OF CONTENTS

Figures

Do house prices impact consumption and interest rate? Evidence from OECD countries using an agnostic identification procedure[1]

by Christophe André[2], Rangan Gupta [3] and Patrick T. Kanda [4]

1. Introduction

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 & Smets, 2008; Vargas-Silva, 2008; Ghent, 2009; Pavlidis *et al.*, 2009; Ghent & Owyang, 2010; Iacoviello and Neri, 2010; Calza *et al.*, forthcoming and Miller *et al.*, forthcoming) and some other countries (see for example Muellbauer & Murphy, 2008; Bassanetti & 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.* (forthcoming). Goodhart & 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.* (forthcoming) provides a trans-Atlantic comparison of responses to shocks in the US and the aggregate euro economy based on a structural VAR (SVAR) and Ludwig and Sløk (2004) takes a panel cointegration approach for sixteen OECD countries to investigate links between stock and house prices and private consumption.[5]

Against this backdrop, using quarterly data, our paper analyzes whether real house price movements have significant spillover effects on consumption decisions in the seven major OECD countries, namely, Canada (1970:01-2009:04), France (1978:01-2008:04), Germany (1970:01-2009:04), Italy (1975:01-2008:04), Japan (1970:01-2009:04), United Kingdom (UK, 1970:01-2008:04) and the United States (US, 1970:01-2010:01). 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 restrictions on some variables for a certain duration. The responses of the variables of interest are, however, agnostically left open.[6] These six variables are chosen to appropriately identify a housing demand shock, and are also in line with the work of Musso *et al.* (forthcoming). 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.* (forthcoming), emanates from the theoretically inconsistent behavior of the impulse response functions in some cases following a house price shock, details of which are presented in Section 3.2.1. It must be pointed out that

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1 An earlier version of this paper is published in the University of Pretoria Department of Economics Working Paper Series (No. 2011/18). The views expressed in this paper are those of the authors and do not necessarily reflect those of the OECD or the governments of its member countries. The authors would like to thank Robert Ford for useful comments and suggestions and Olivier Besson for excellent editorial support.

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

6 Please refer to Section 2 for further details.

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.[7] Having said that, it is not always the case that sign restrictions are superior to short-run 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.* (forthcoming), sign 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.*, forthcoming). 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 theoretically consistent behavior of the variables under consideration.

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). 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, forthcoming; 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 & Notarpietro (2008) and Finocchiaro & 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, does 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

7 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 to the housing market, see Gupta, Jurgilas & Kabundi (2010); Gupta & Kabundi (2010); Gupta, Jurgilas, Miller & van Wyk (forthcoming) and Gupta, Jurgilas, Kabundi & Miller (forthcoming).

price movements. Some evidence of simultaneous interest rate response to house price shocks in Sweden and the UK have been provided by Bjørnland & Jacobsen (2010) based on SVAR models, with monetary policy shocks being identified based on a combination of both short- and long-run restrictions. Musso *et al.* (forthcoming) 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 in particular from the wealth effect of a positive shock in real house prices.

Except for the case of Japan, the international evidence on the interest rate response to a house price shock is limited to the euro area, 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 the major seven 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 types of methods identifying the housing demand shock. Finally, Section 4 concludes.

2. Methodology

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

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

where:

Y_t represents a $m*1$ vector of endogenous variables at time $t = 1-l,...,T$. 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 mortgage loans (b). c, ri, hpr and b are expressed in real terms (generated by dividing the nominal values of each series by the price deflator), and all variables are in their logarithmic-form, of course barring the nominal interest rate.[8] The optimal lag length is determined based on the Akaike Information Criterion (AIC).[9] At any date t we therefore have,

$$Y = [\,p,c,ri,i,hpr,b\,]';\quad (2)$$

B_0 is $m*1$ vector of constants; $B_{(j)}$ j $= 1,....,l$ represent $m*m$ coefficient matrices;

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.* (forthcoming), 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 & Neri (2010) and Musso *et al.* (forthcoming), 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 react simultaneously to this shock, so that the shock cannot be dubbed a positive technology shock, including of the "positive news" type shock.[10]

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

9 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.

10 Note, besides the studies of Ludwig & Sløk (2004); Goodhart & Hofmann (2008); Das *et al.* (2011) and Musso *et al.* (forthcoming) discussed in the introduction as providing international evidence on the spillover effect of house price shock, Aspachs-Bracons & Rabanal (2011) indicates of significant effect of Spanish house price shocks on consumption and residential investment as well based on a VAR. In this model, the housing demand shock was identified as the shock that affects housing prices within a period, after taking into account the effect that changes in the interest rate have on housing prices. However, the results of this paper also indicated a persistent decline in the interest rate. Thus, as indicated in Musso *et al.* (forthcoming), we cannot distinguish the shock from an expansionary monetary policy shock, and, hence, cannot place too much of a confidence on these results. Demary (2009) also provides some evidence on the effect of a house price shock on output and interest rate on 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

The impulse responses from a VAR are highly non-linear functions of these coefficients. Hence, to properly assess the statistical significance of the generated 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 Σ 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) on the responses of all variables in the VAR barring private consumption and 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.[11]

As far as the specifics of Uhlig's (2005) agnostic identification procedure is concerned, it can be described as follows[12]: 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, …, K. Further, to account for identification issues, Uhlig (2005) recommends that we supplement 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 $k = 0,...,K$, 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;

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the Gross Domestic Product (GDP) and interest rate.

11 Note, Musso *et al.* (forthcoming) 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 we are interested in appropriately. Interestingly, we observed that if we theoretically restrict the movement of the mortgage lending rate to a house price shock, the measure of the monetary policy instrument also behaved in the same way.

12 Please refer to the original source for further details.

6. stop the process after acquiring n_3 IRF with the required sign. The error band are computed 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. 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 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. 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 year 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 national authorities. 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.

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 7). Real house prices increase on 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, 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 shock can affect private consumption through several channels. First, a rise in residential investment produces a multiplier effect 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 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 & Johansson, 2011). Second, there is a wealth effect, or more precisely a collateral or liquidity effect.[13] As house prices increase, more collateral is available to secure mortgages, loosening the borrowing constraint of households (Aoki, 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 1½ 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*. (2010). 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. In Japan, there is a short-lived initial increase in consumption. As the response of mortgage loans is negative, the increase in consumption is

13 The collateral or liquidity effect is difficult to separate from a wealth effect in practice. However, the theoretical grounds for the existence of a pure housing wealth effect are limited (Buiter, 2008). The fact that housing wealth effects are strongest in countries with sophisticated mortgage markets tends to confirm this theoretical prior.

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).

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 a lifted by a third factor, for example an increase in financial wealth or future income expectations.

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 why 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 consistent with a reaction by monetary authorities to house prices insofar as they convey information about the future inflation path. The strongest interest rate responses in relation to the increase in inflation have been in Canada, Japan and the UK. While in Canada a sharp monetary policy reaction might be explained by the potential inflationary pressures created by a strong response of residential investment and consumption, concerns about unsustainable developments in house prices may have played a role in the policy decisions in Japan and the UK.

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).

Figure 1. Canada: Choleski (Recursive) Identification Scheme Results

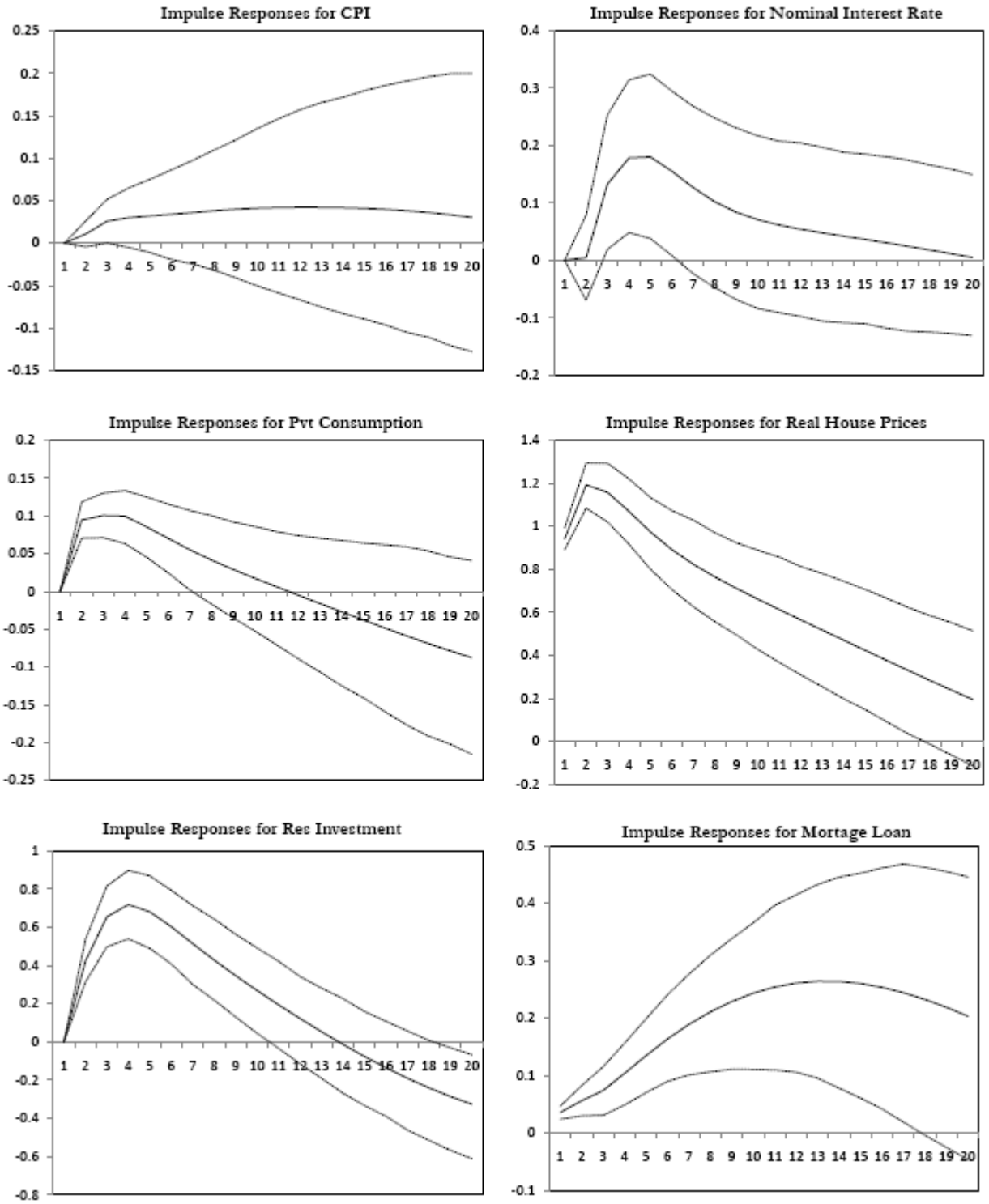


Figure 2. France: Choleski (Recursive) Identification Scheme Results

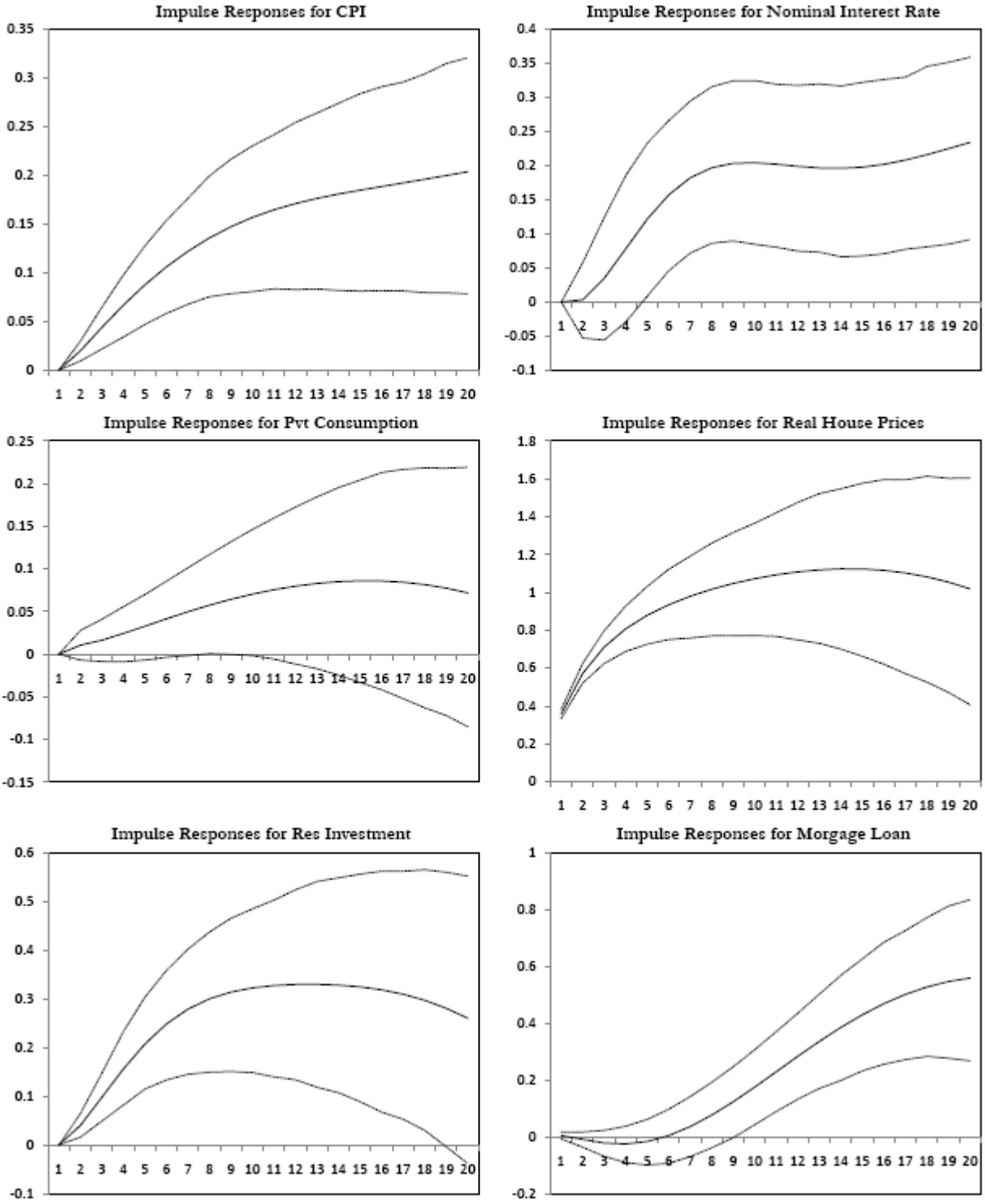


Figure 3. Germany: Choleski (Recursive) Identification Scheme Results

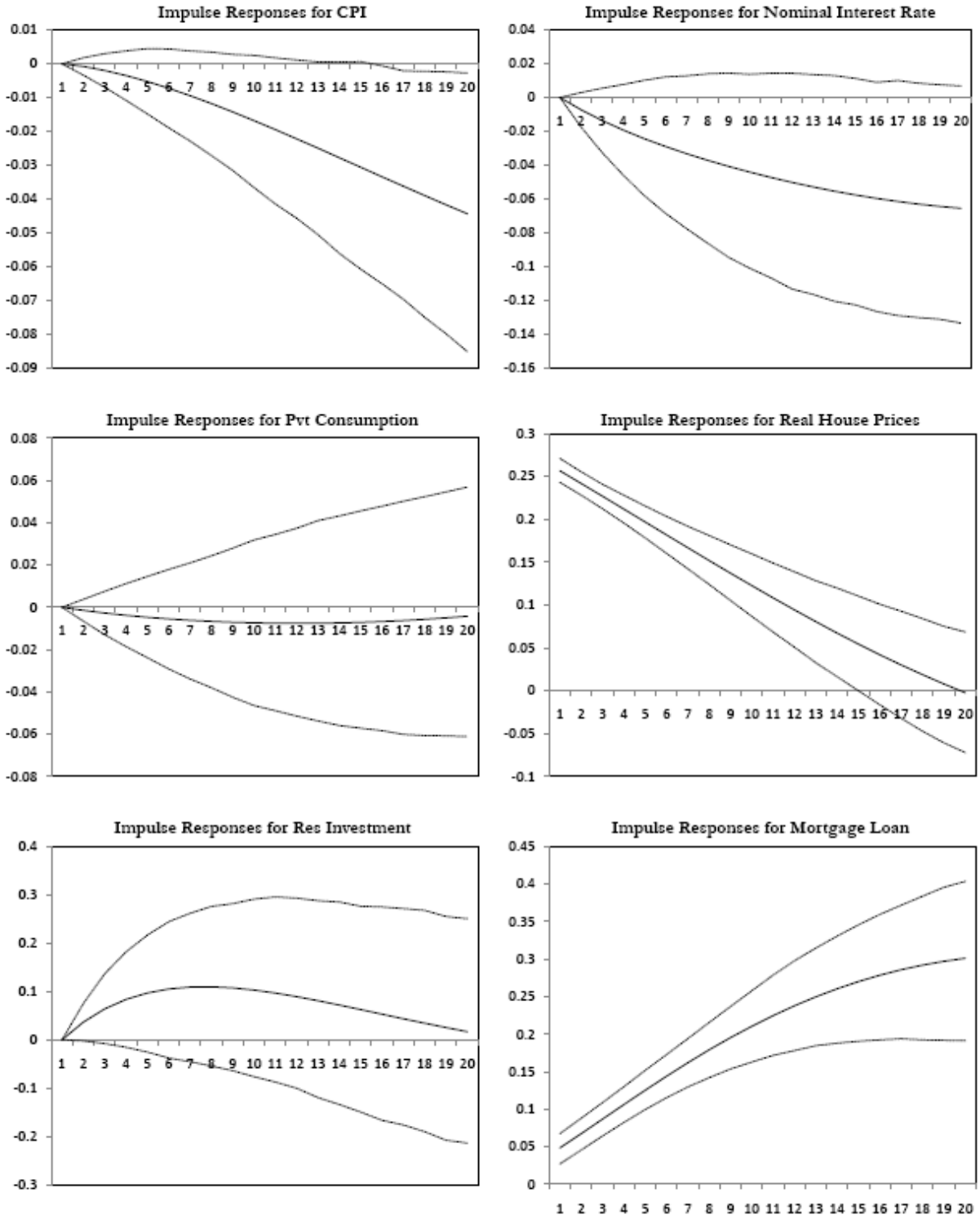


Figure 4. Italy: Choleski (Recursive) Identification Scheme Results

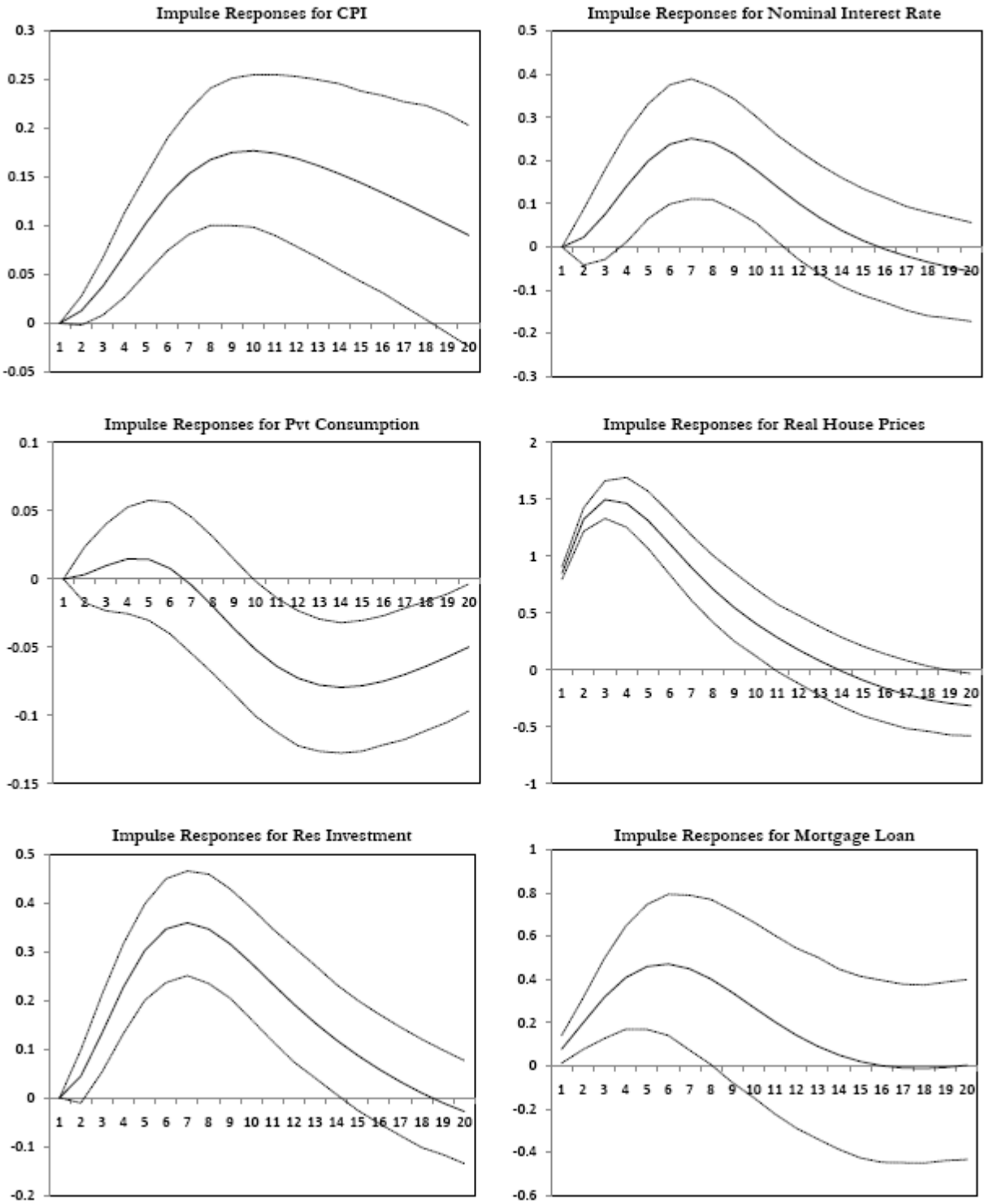


Figure 5. Japan: Choleski (Recursive) Identification Scheme Results

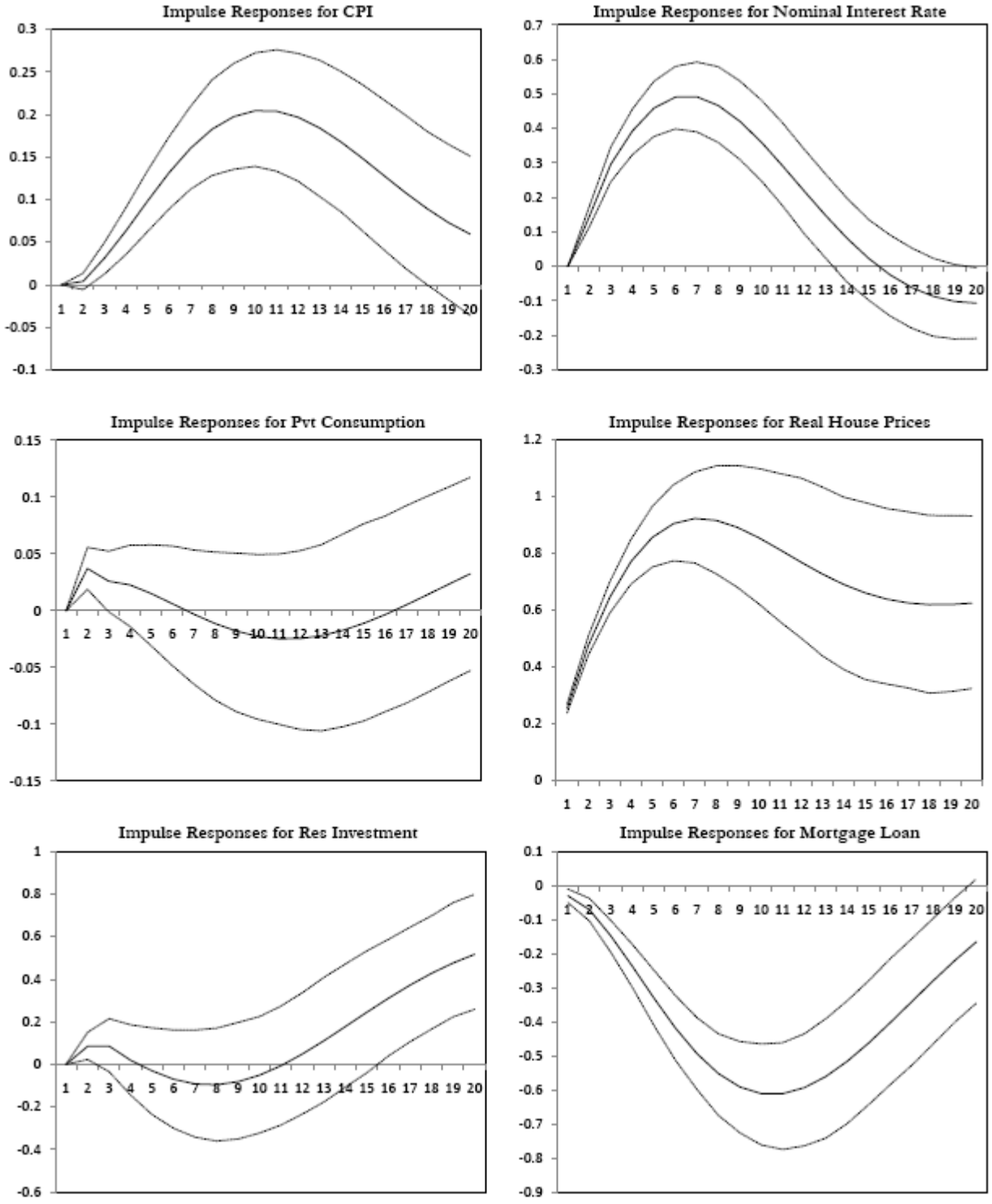


Figure 6. UK: Choleski (Recursive) Identification Scheme Results

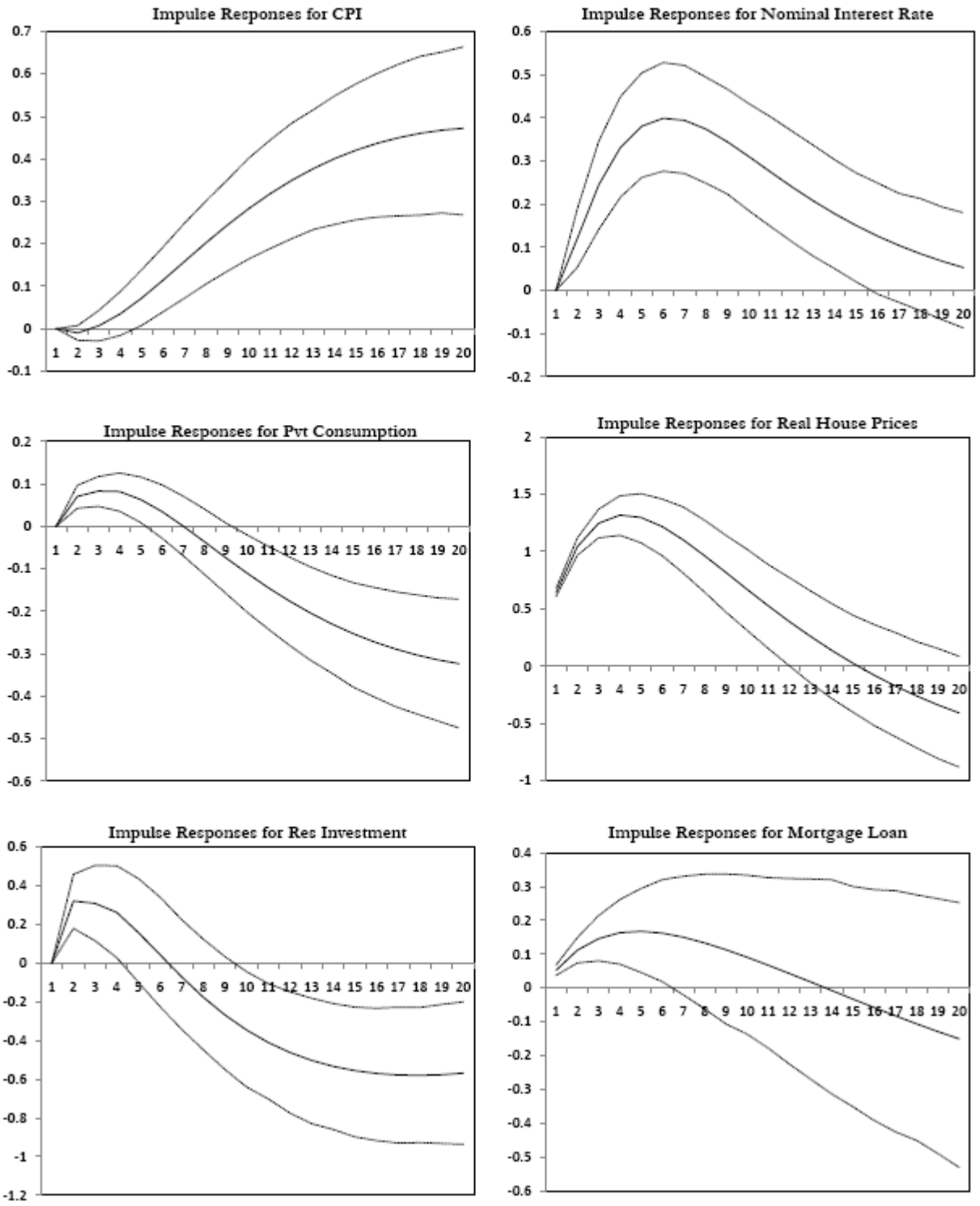
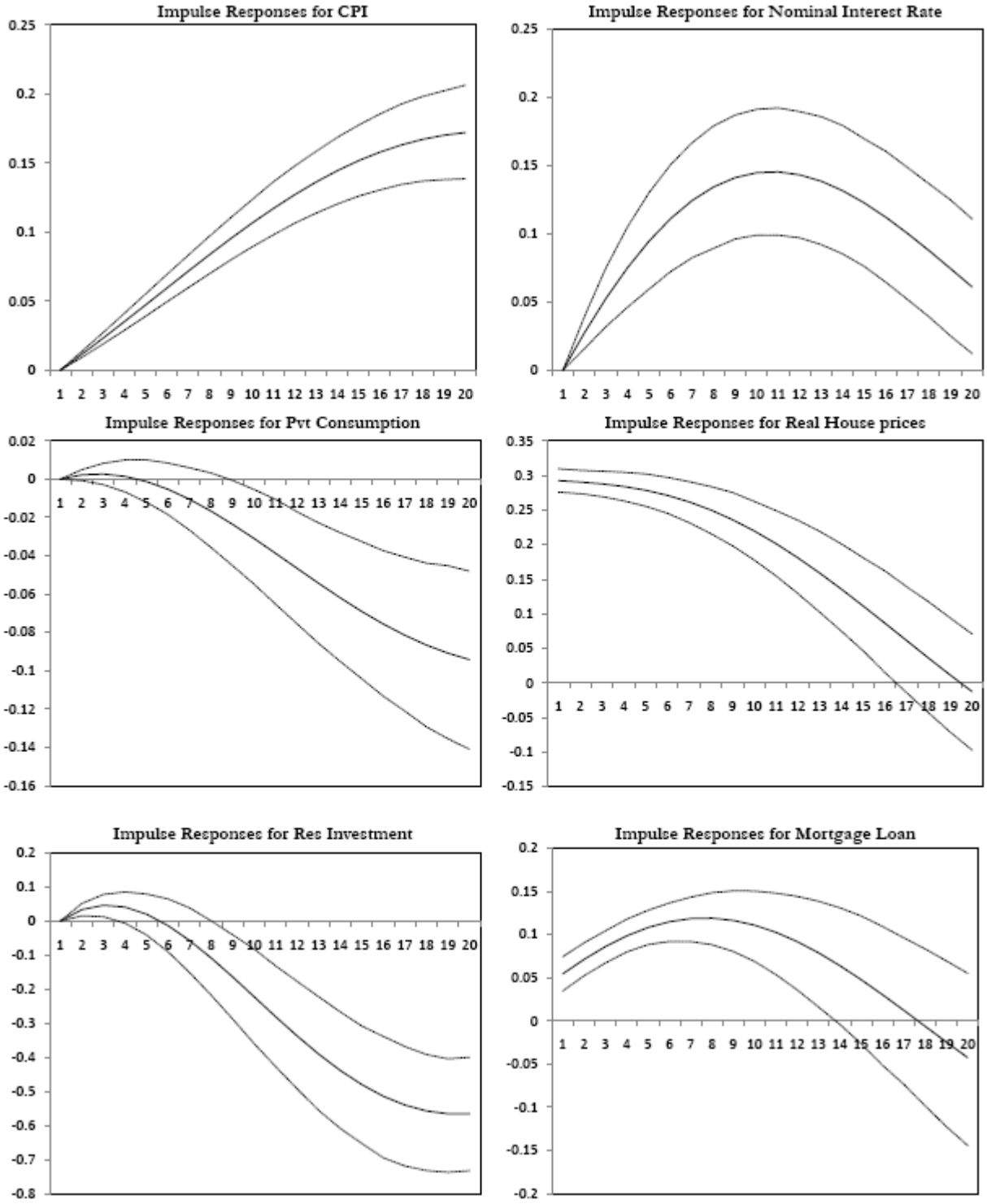


Figure 7. US: Choleski (Recursive) Identification Scheme Results



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 negative response of mortgage loans in France and Japan is incompatible with a housing demand shock. 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 8 to 14). 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 11 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 houses are financed with mortgages. 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 10 quarters in France and the UK. The magnitude of the response differs between countries, with the peak impact ranging from less than 0.3% in France and Italy to 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 & 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 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 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 France, the rise in consumption remains significant until the 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 is not surprising. 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 & 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 11 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, coming with a lag of two quarters in Germany and the UK, three quarters in Japan and six quarters in the US. The delay suggests 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. In Canada, France and Italy, the interest rate response is insignificant.

Figure 8. Canada: Impulse Responses with sign restriction

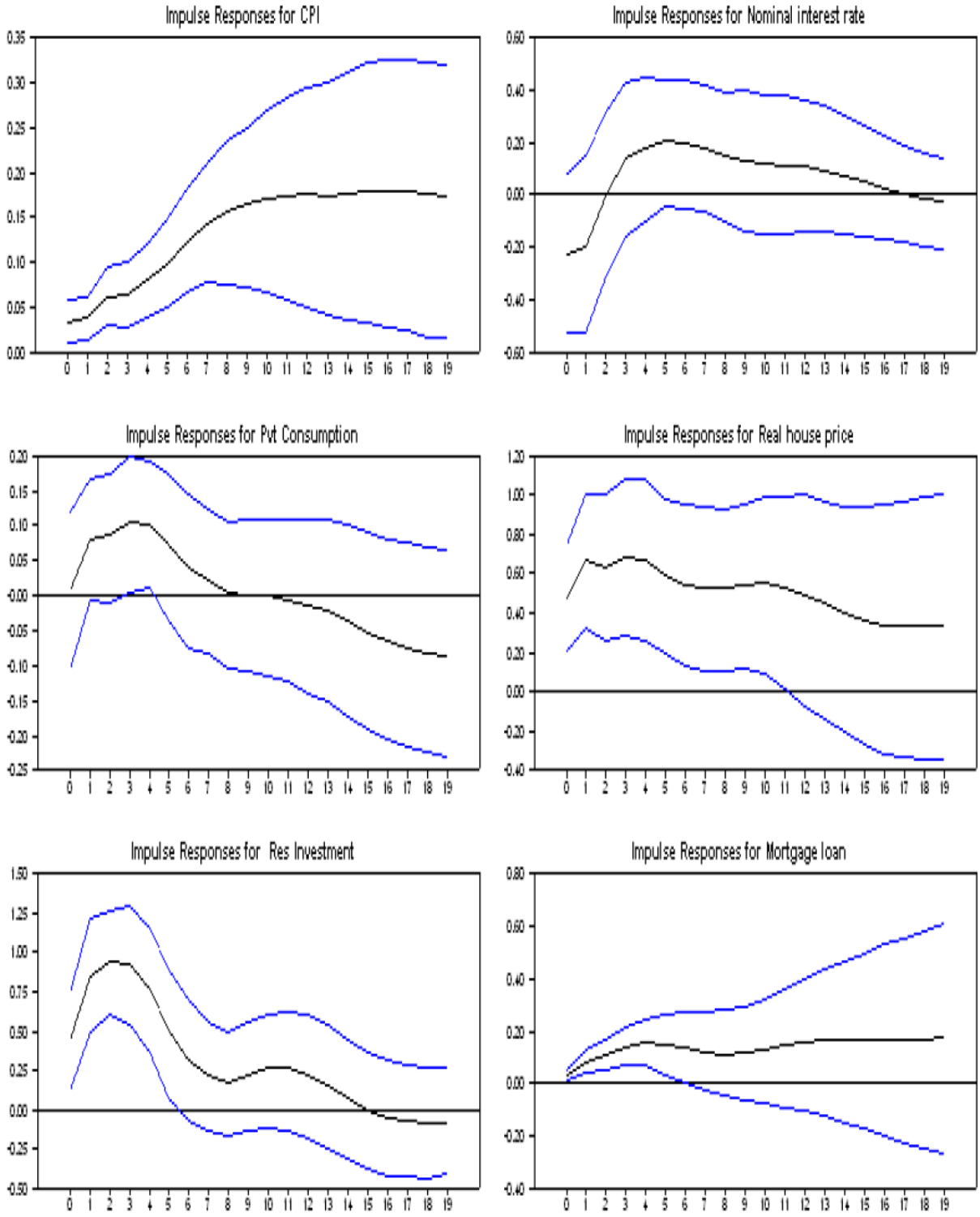


Figure 9. France: Impulse Responses with sign restriction

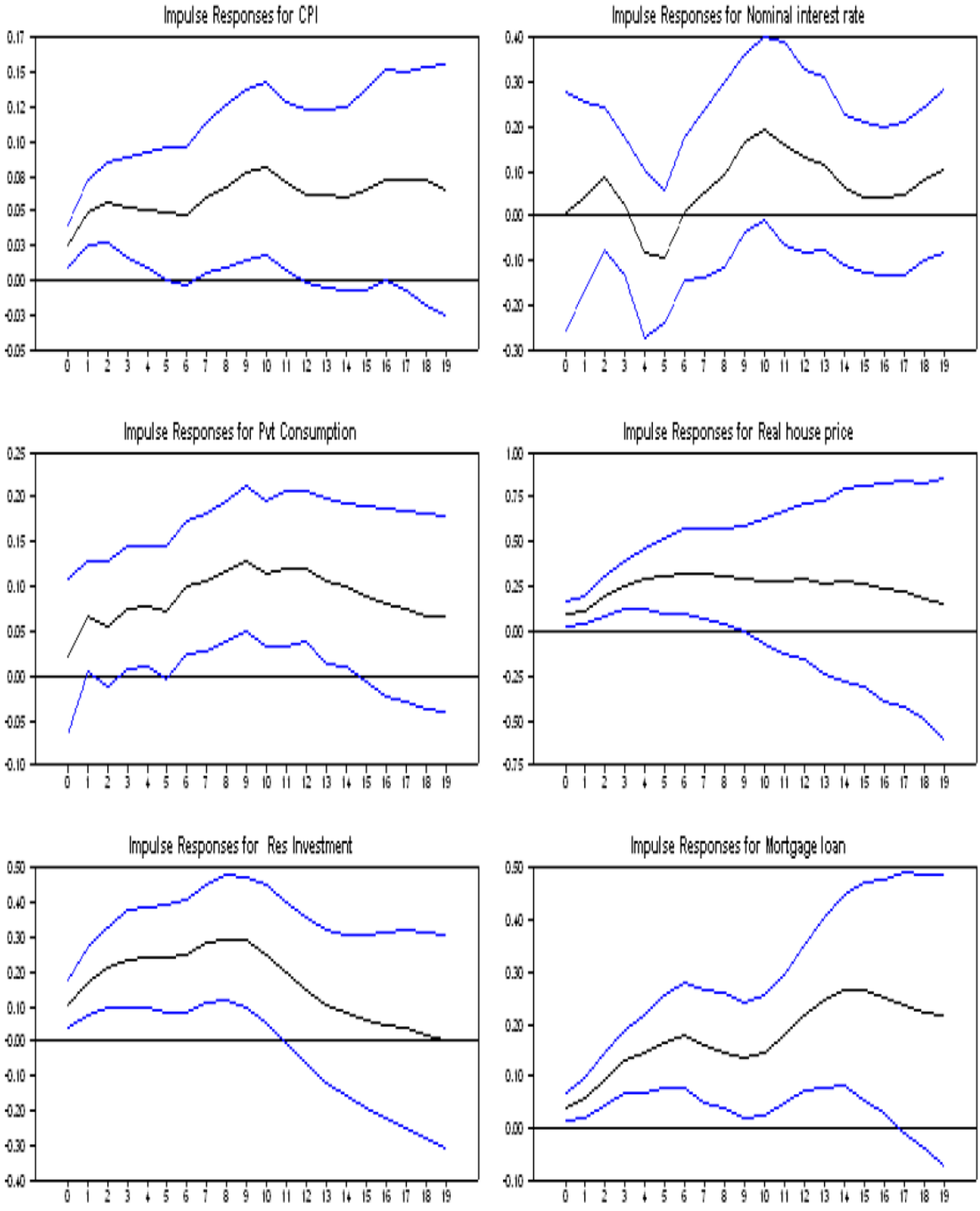


Figure 10. Germany: Impulse Responses with sign restriction

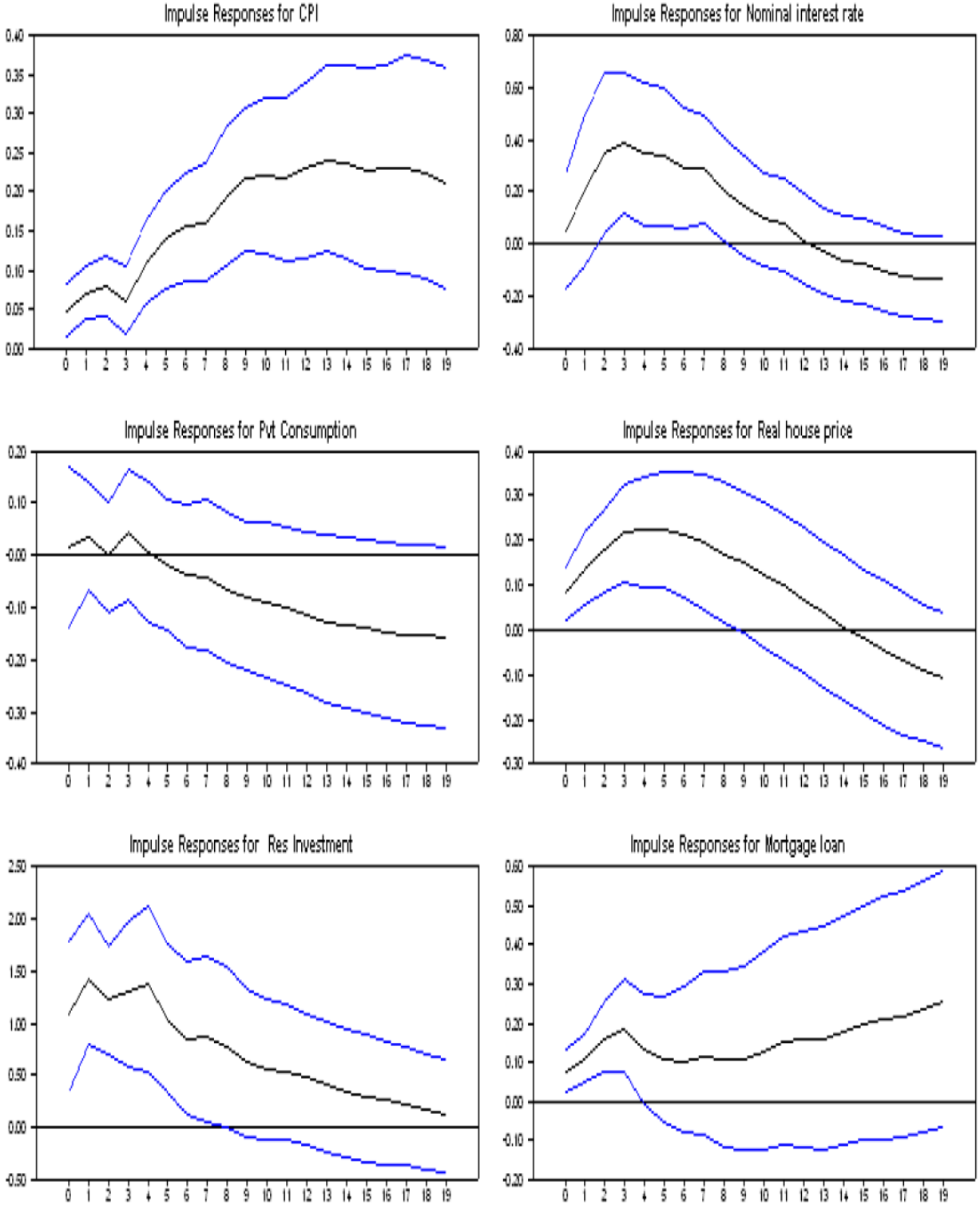


Figure 11. Italy: Impulse Responses with sign restriction

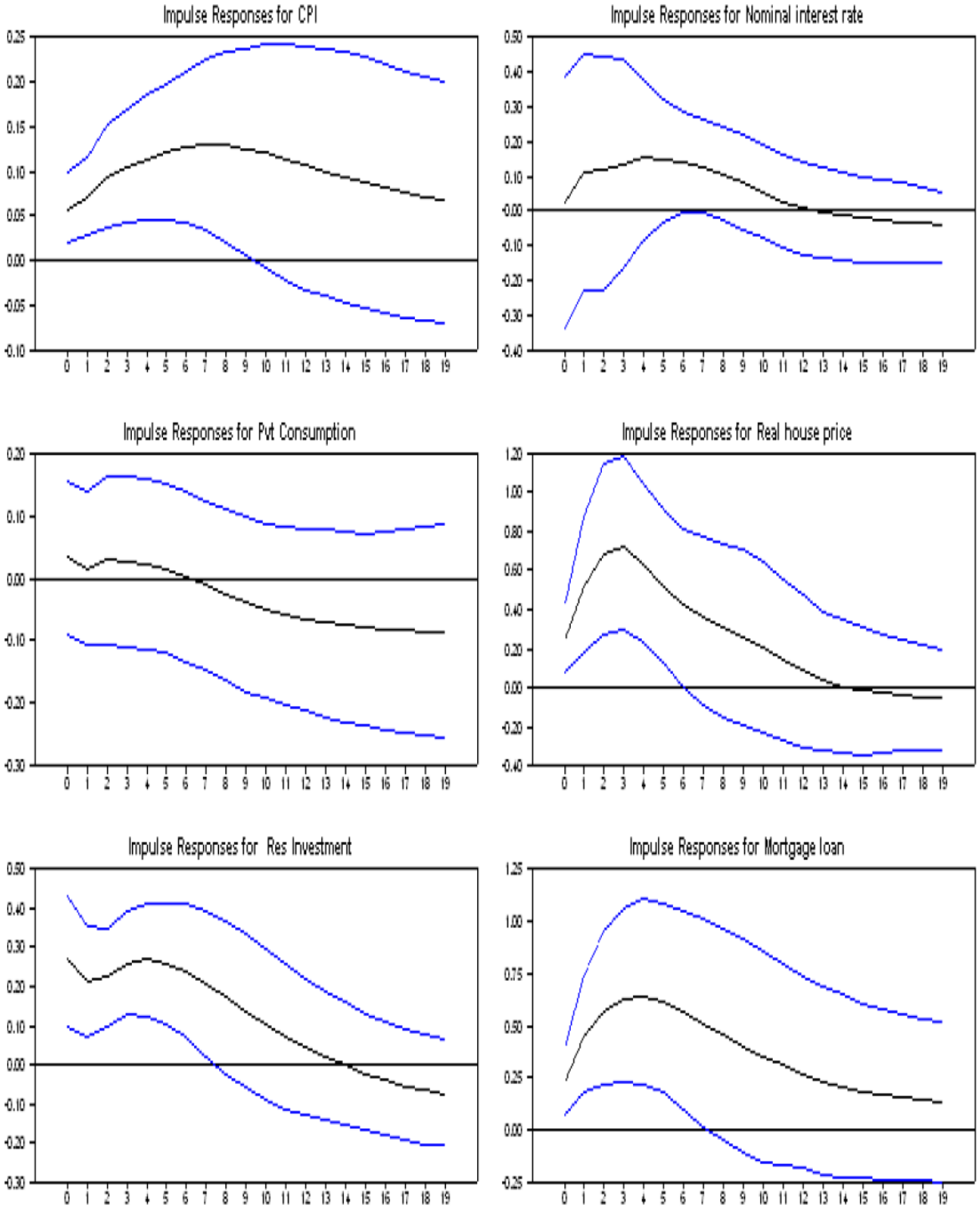


Figure 12. Japan: Impulse Responses with sign restriction

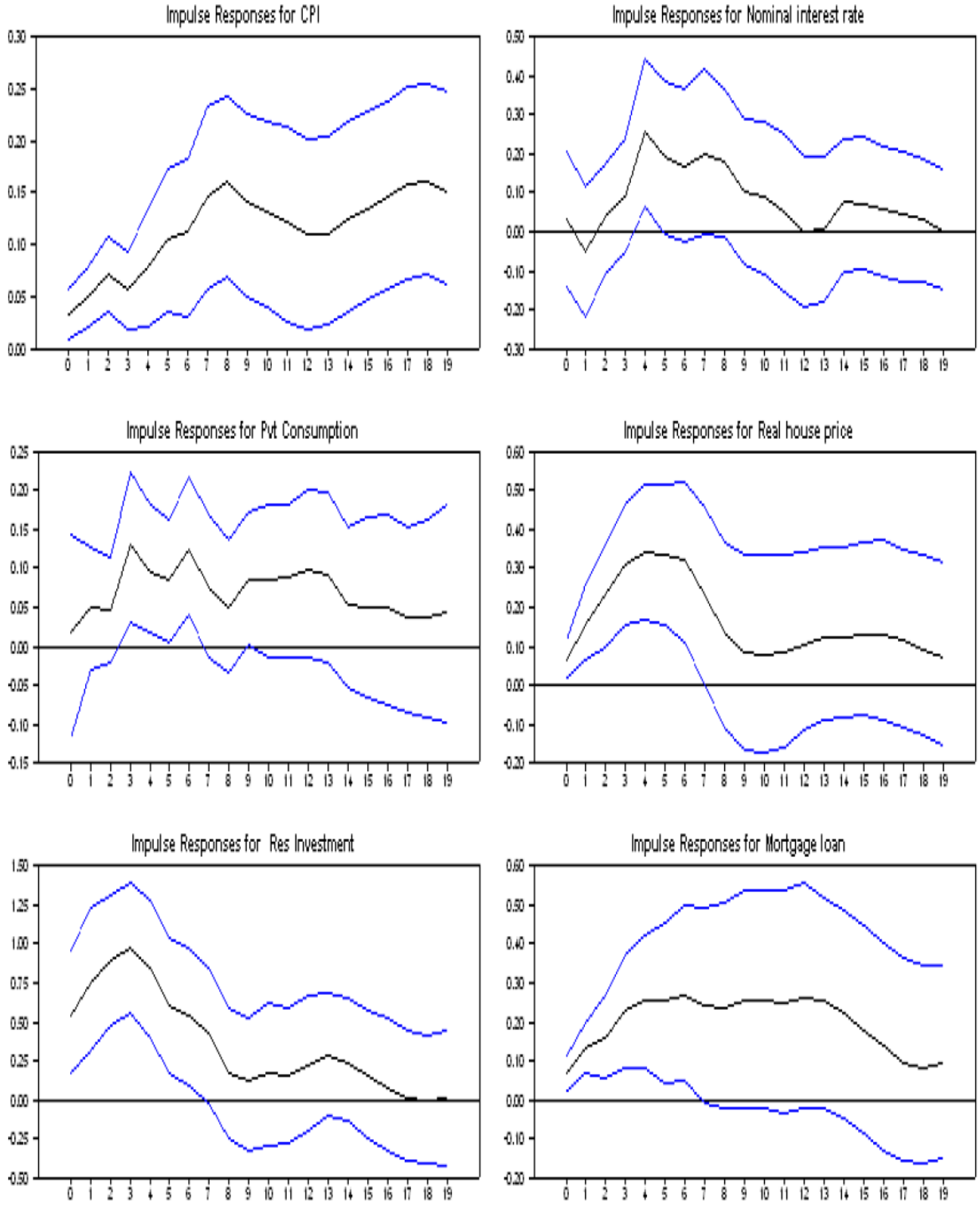


Figure 13. United Kingdom: Impulse Responses with sign restriction

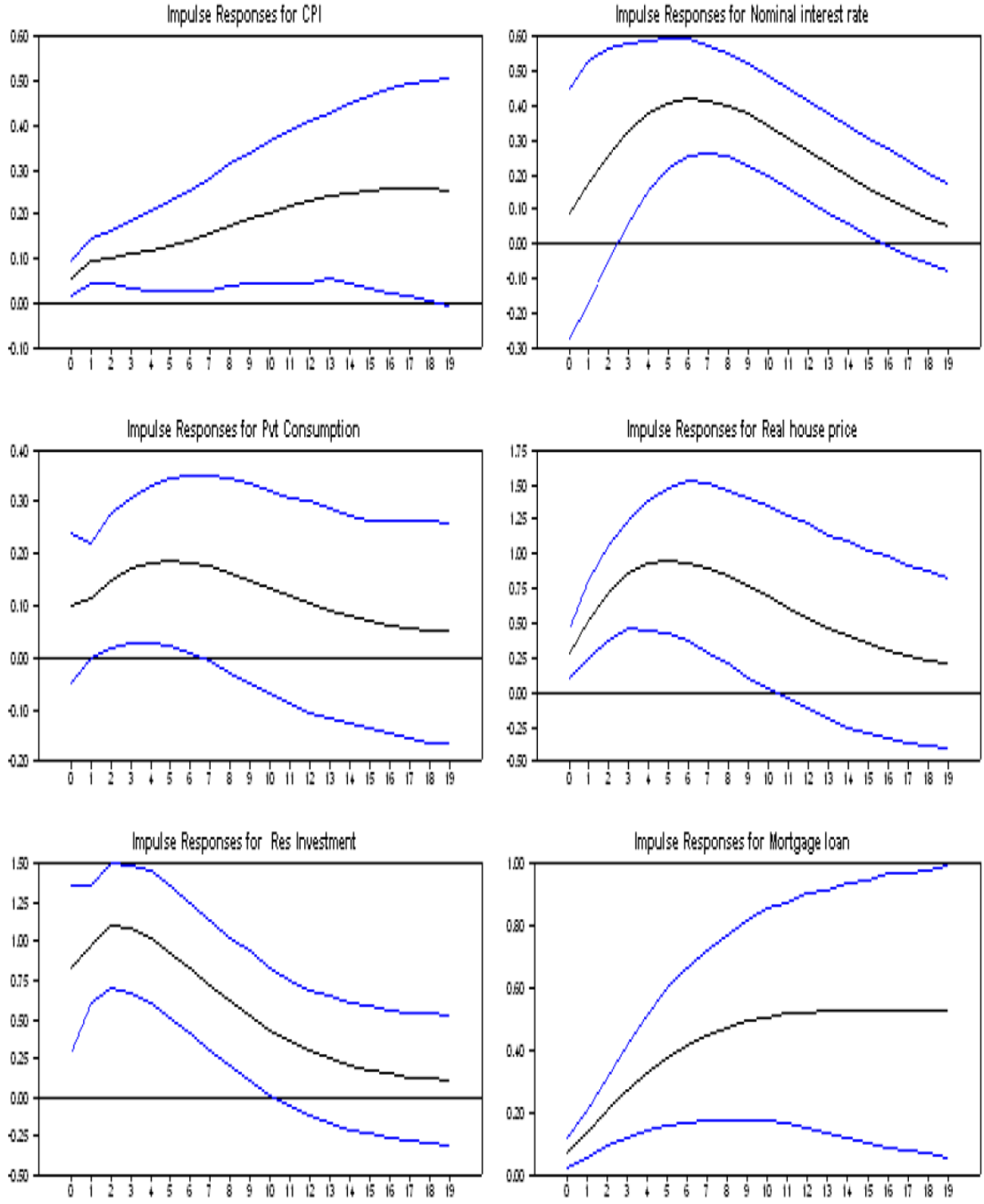
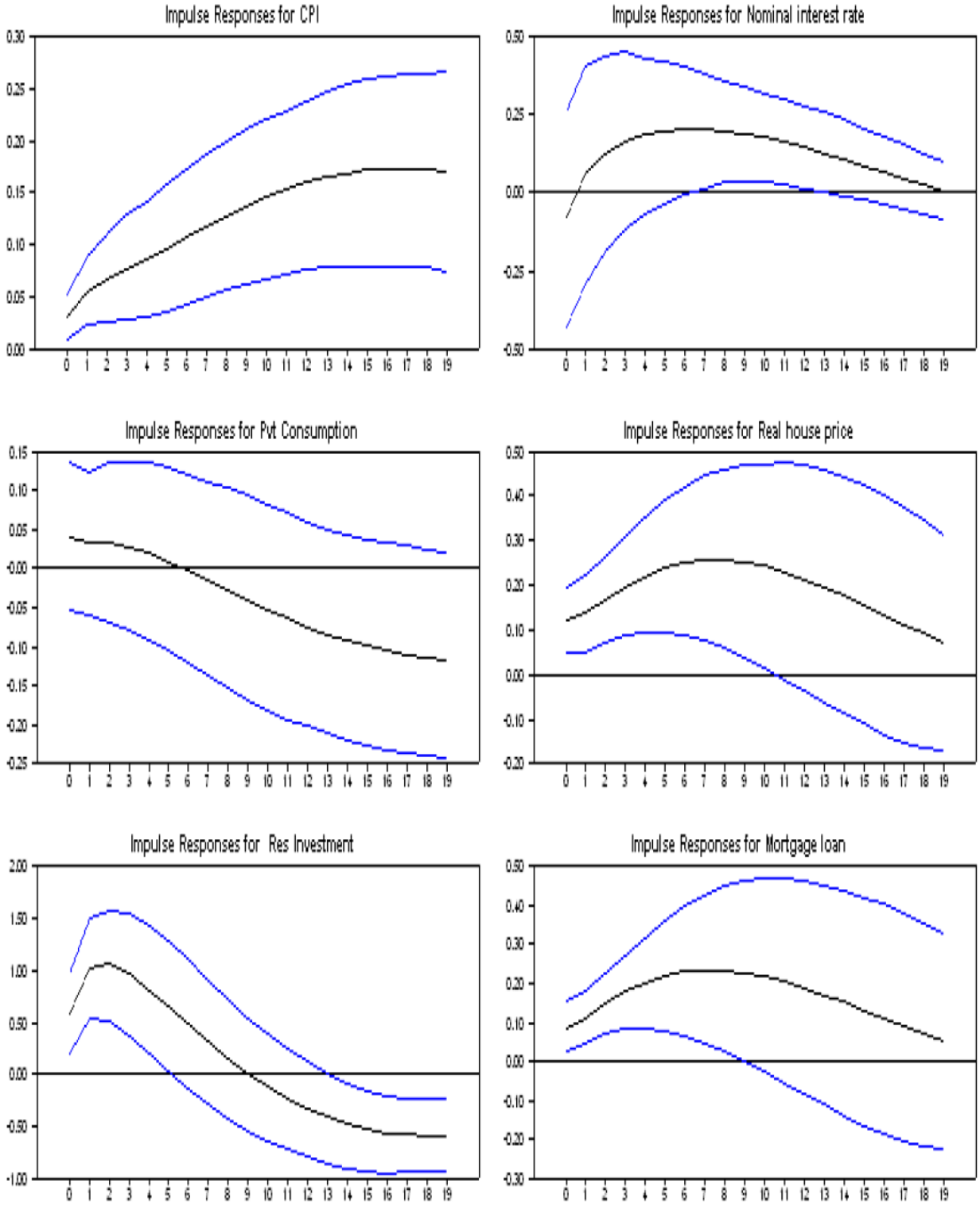


Figure 14. United States: Impulse Responses with sign restriction



3.2.3. Variance decomposition (nominal interest rate & 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 A.1 to A.7 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.* (forthcoming) 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 all seven major 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 the seven major 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 and 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 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.

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APPENDIX

Figure A.1. Canada: Fraction of variance explained with pure-sign approach

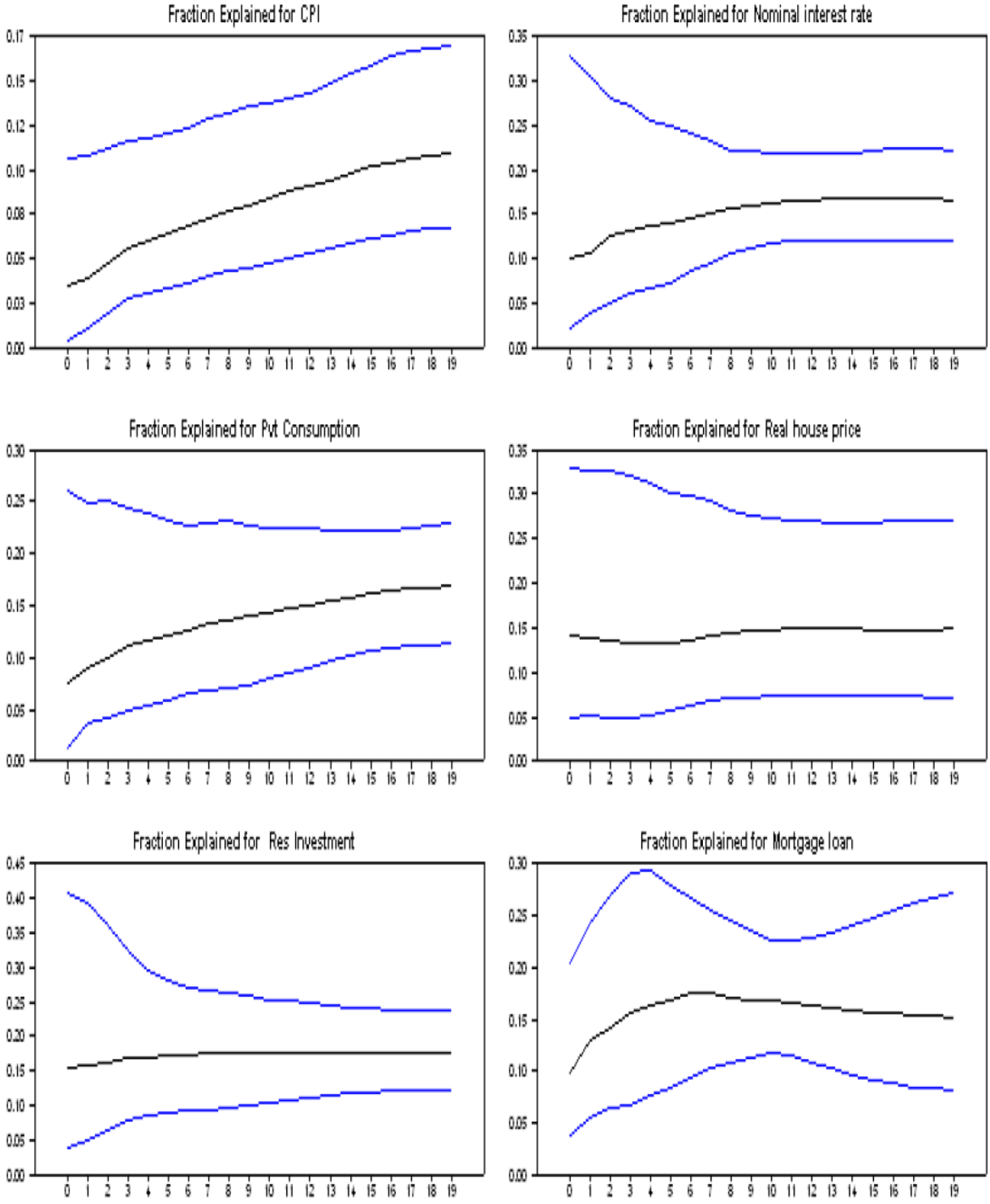


Figure A.2. France: Fraction of variance explained with pure-sign approach

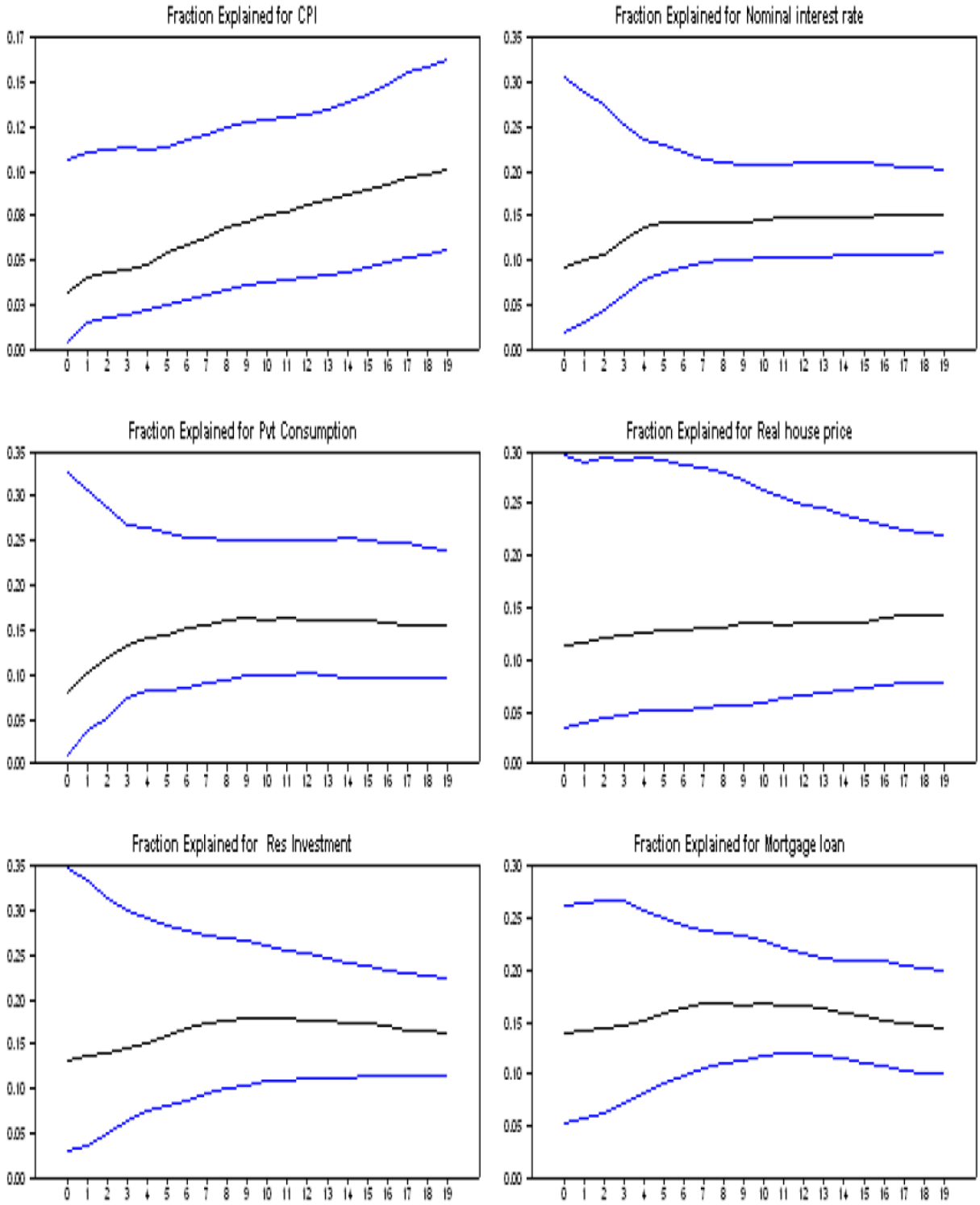


Figure A.3. Germany: Fraction of variance explained with pure-sign approach

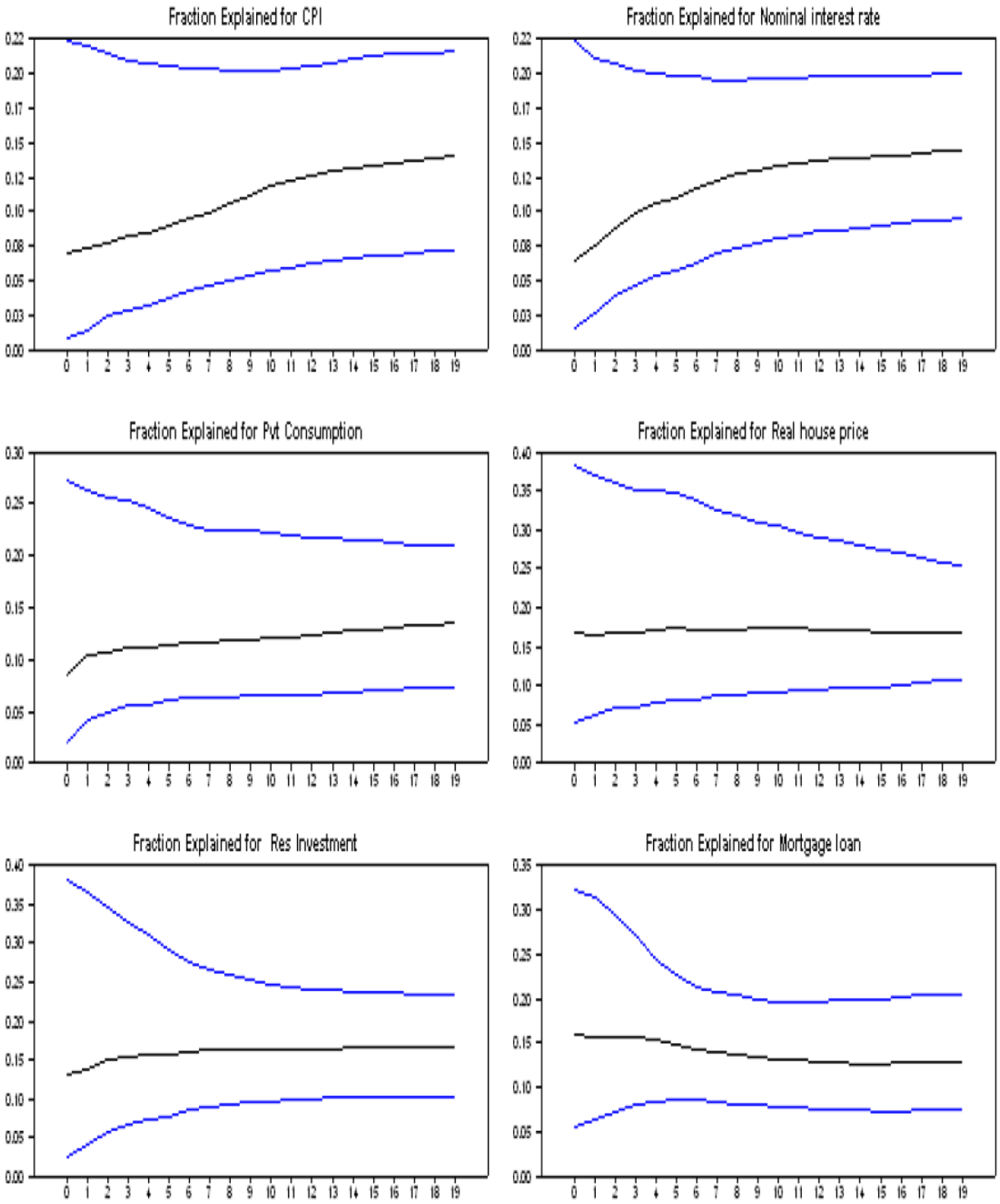


Figure A.4. Italy: Fraction of variance explained with pure-sign approach

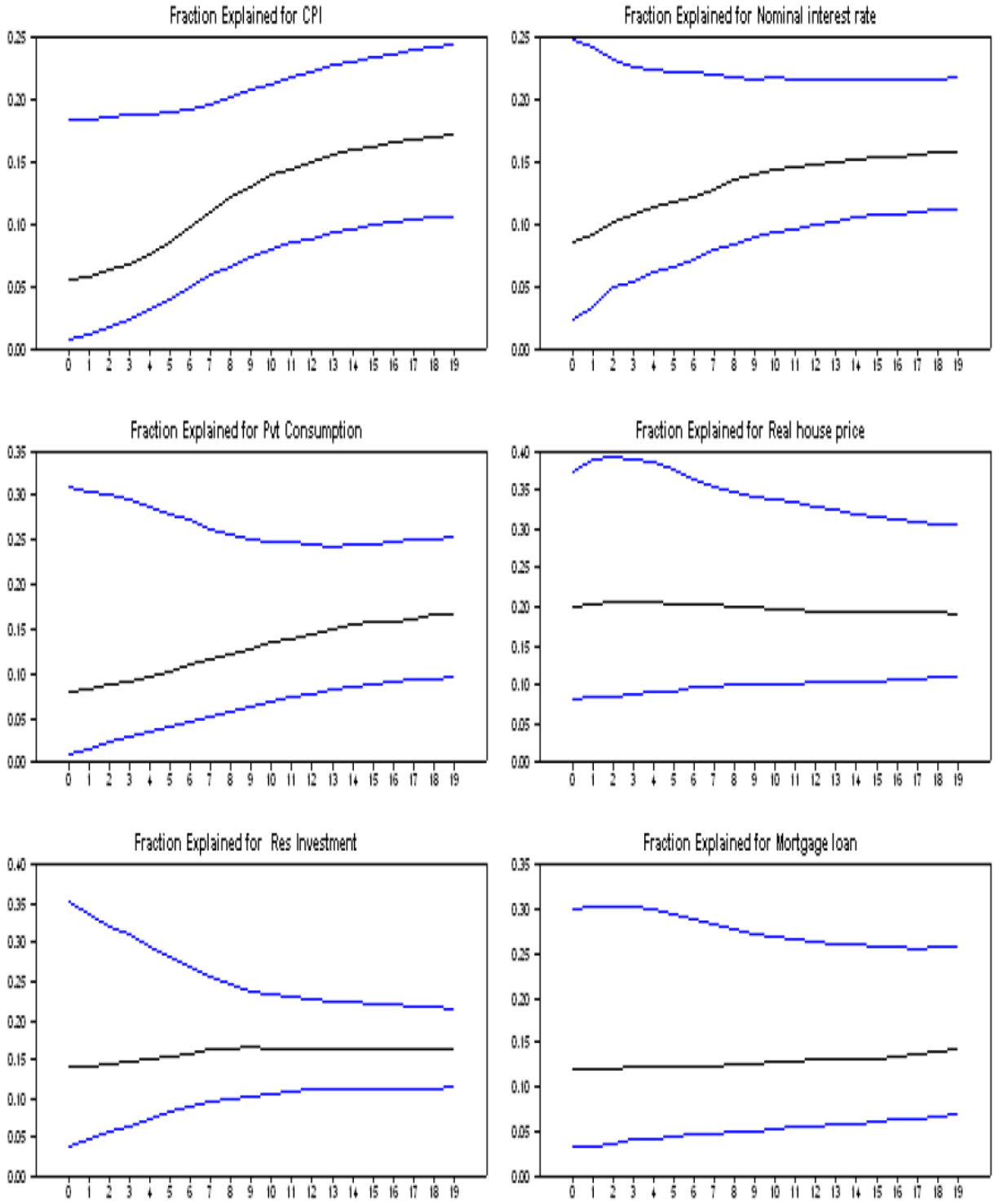


Figure A.5. Japan: Fraction of variance explained with pure-sign approach

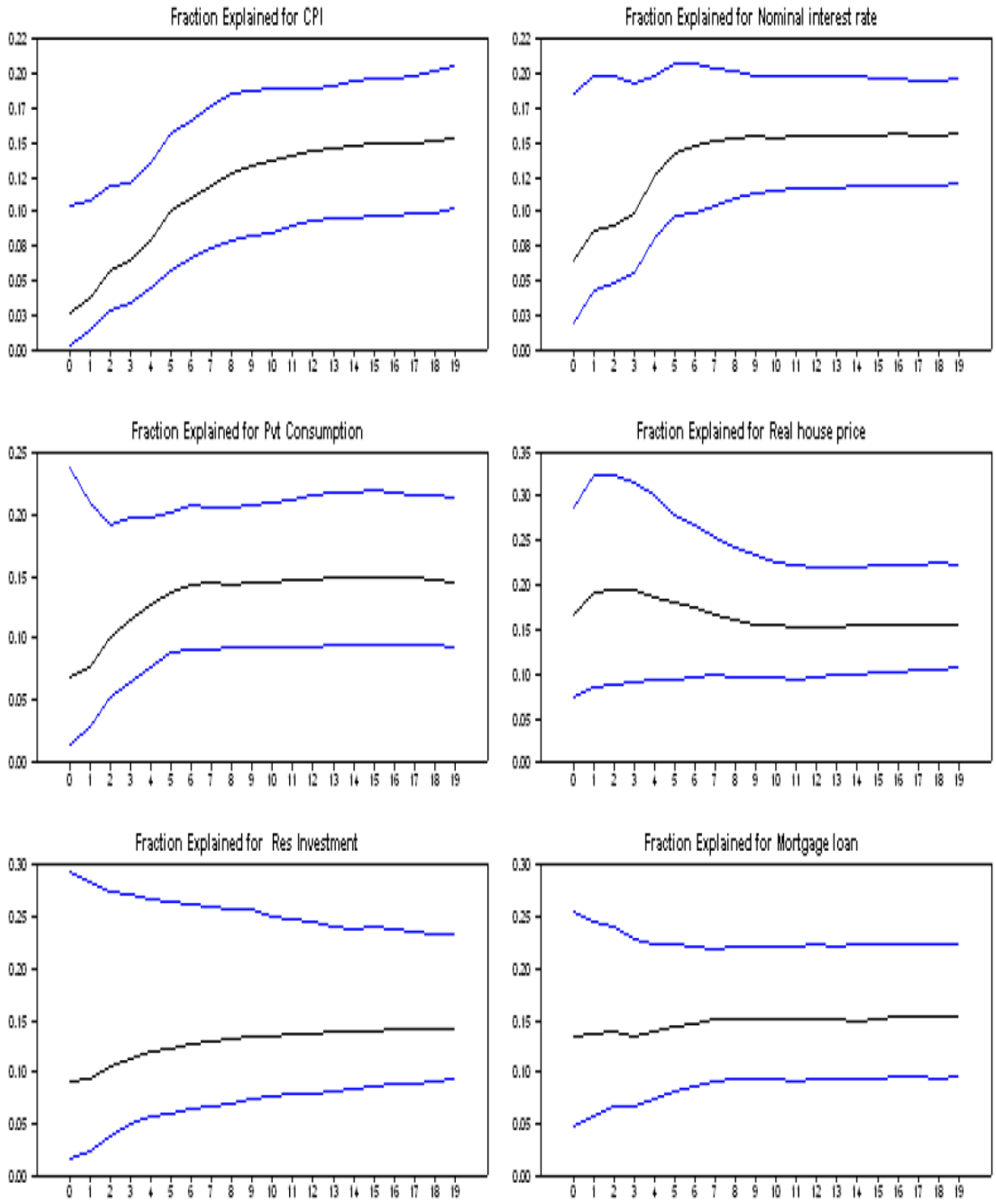


Figure A.6. United Kingdom: Fraction of variance explained with pure-sign approach

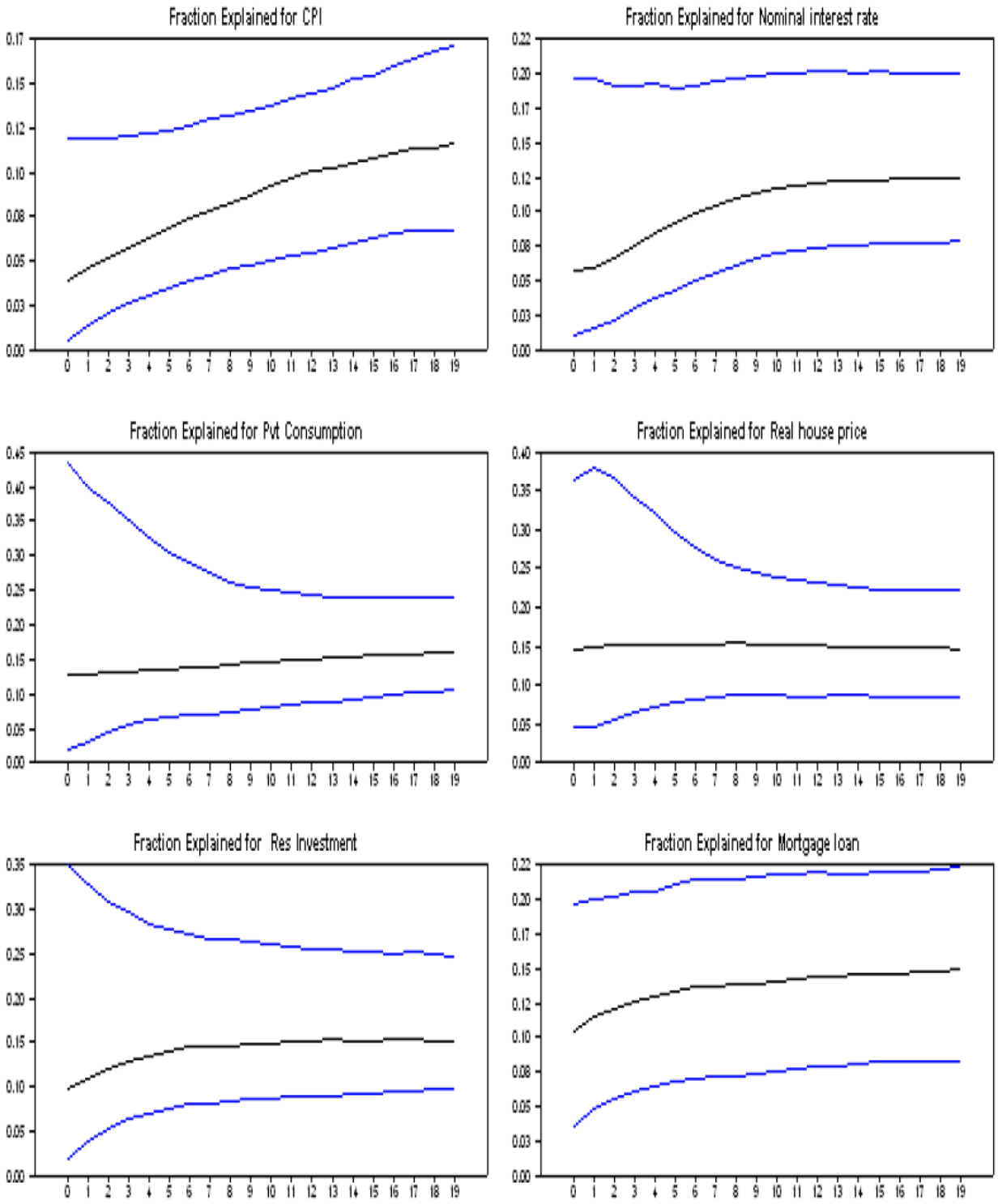
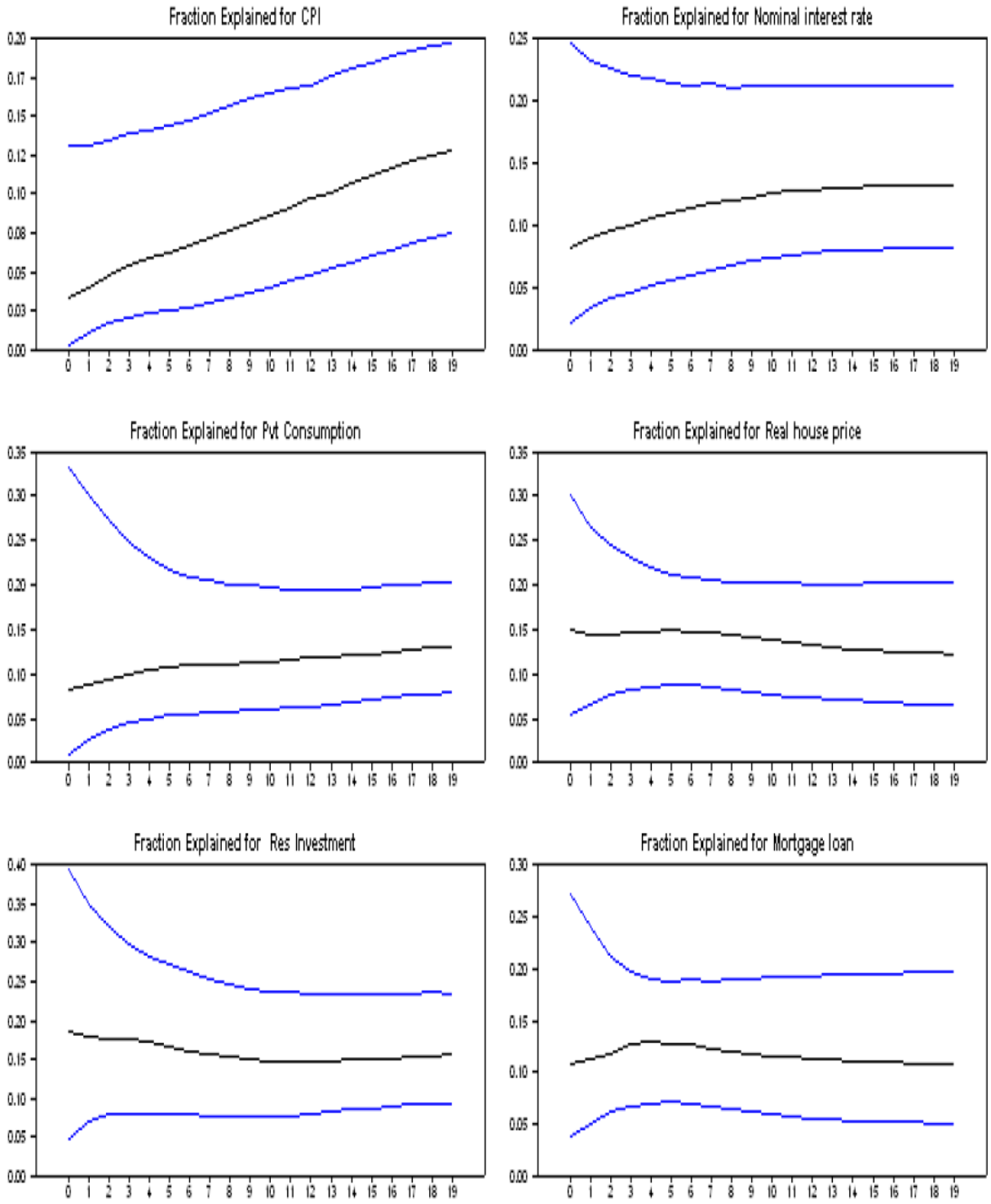


Figure A.7. United States: Fraction of variance explained with pure-sign approach



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