The international transmission of house price shocks*

O. de Bandt,† K. Barhoumi,‡ and C. Bruneau,§

February 2009

Abstract

Using a sample of house prices in OECD countries, we estimate single equation models on the basis of a General-to-Specific approach and run Favar models. We show that the housing prices are driven by domestic fundamentals, notably interest rates. In addition there is evidence of international transmission of housing prices since the first common factor derived for world housing prices explains the dynamics of housing price in the UK, Australia and to a smaller extent in France.

Key words : housing, factor models, Vector Autoregressive models
JEL : G33, E32, D21, C41

*Many thanks to Jean Ludovic Audret for helping assemble the database. All errors remain ours. The opinions expressed are not necessarily those of the Banque de France or the Eurosystem.

†Banque de France, E-mail olivier.debandt@banque-france.fr

‡Banque de France, E-mail karim.barhoumi@banque-france.fr.

§Banque de France and University of Paris X, E-mail cbruneau@u-paris10.fr.

1 Introduction

The run-up of the housing bubble as well as the housing crisis that erupted in the USA in the summer of 2006, followed by the crisis in the UK as well as the sharp fall in house prices in Ireland and Spain, have raised questions of possible international transmission of shocks across countries (Terrones and Otrok, 2004).

Several explanations are possible of such a phenomenon. First of all, house prices maybe driven by fundamentals that are either real macroeconomic or financial variables (see Goodhart and Hoffman, 2004 for the role of credit variables). If the cycles of fundamentals are correlated, and house prices are driven by fundamentals, then house prices are likely to comove. Second, news on house prices in some countries may lead investors to revise their expectations on house prices in other countries. Another possibility, is that the channel of transmission is time variant, leading to possible contagion if house price changes are more significant when prices are decreasing, or during a crisis. While the last feature is beyond the scope of the current paper and left for future research, we document here the role of macroeconomic fundamentals in the dynamics of house prices and the relevance of international comovements using factor analysis.

2 Litterature review

House prices in many industrial countries have increased unusually rapidly in recent years and in some cases these increases do not seem to be fully explained by economic fundamentals. The dynamics of house prices has indeed been mainly studied at the national level (Tatsanoris and Zhu, 2004), housing markets being viewed as "local" in nature. Goodhart and Hoffman (2004) stress the need to extend the set of fundamentals to money and credit variables. In that context, the transmission across markets is mainly national, between local and regional markets. However, Del Negro and Otrok (2007) conclude that the early 2000s in the US were different from before, with a much larger contribution of national as opposed to state level components.

In contrast, the analysis of international transmission of housing prices is less developed with the exception of Vansteekiste and Hiebert (2009) who use a Global VAR approach to study comovements of house prices in the euro area and conclude to limited spillovers across countries. Earlier, Terrones and Otrok (2004) had developed a systematic analysis of the dynamics of house prices across a larger number of industrial countries. They show that house prices are highly synchronized and that the house price boom that took place in the early 2000 was unusual in both its strength and duration. Innovative aspects of the analysis are the use of dynamic factor (DFA) models to determine the extent to which house price comovements are explained by global or countryspecific factors and of FAVAR models (for Factor Augmented Vector AutoRegressive models), that combine country-specific variables with factors in VAR-type frameworks.

Before developing the FAVAR-based analysis, the authors investigate the extent to which fundamentals explain the dynamics of house prices. They indeed find empirical evidence in favor of the dependence of house prices on economic fundamentals (real income growth, interest rates), besides a significant contribution of the autoregressive component: house prices appear to be highly persistent with a significant autocorrelation of order one.

The factor analysis consists in extracting factors from different variables (not only the growth rate of house price, but also real stock returns, per capita output, per capita consumption, per capita residential investment, and changes in the short- and long-term interest rates) for 13 industrial countries, over the period 1980-2004. The methods allows to identify complementary factors, namely, a global factor, which affects all variables in all countries, capturing the common shocks affecting these variables, a global housing factor, affecting all house prices in all countries, but not other variables, similarly, a global interest rate factor, capturing common shocks to global interest rates but not to other variables, and so on for each type of variable in the data base.

Moreover, country-specific factor are estimated, reflecting the common shocks to the country-specific variables.

The results are that a large share (about 40 percent on average) of house price movements appears to be due to global factors, which reflect global co-movements in interest rates, economic activity, and other macroeconomic variables, which in turn result from common underlying shocks. The overall global factor affecting all variables explains (on average) about 15 percent of movements in house prices, while the global housing factor—capturing global shocks to housing markets alone— explains —on average— 25 percent of house price movements, with a clear heterogeneity in the contribution of the common

Our aim is to estimate the same type of FAVAR models from our data base described hereafter. We use a slightly different database and extend the sample to include the burst of the housing bubble. We implement a more robust approach to assess the additional explanatory power of international house prices : we first estimate country-by-country models of real house prices based on domestic macroeconomic fundamentals, based on the usual view that housing market are "local" (i. e. respond to regional or national determinants); we then consider whether international house prices, derived from common factors, help provide better models.

In the following section we recall briefly how to build a FAVAR model, which may be of two types, and explain how we implement such a methodology in our case.

1. Model FAVAR in the lines of Stock and Watson (2005)

One considers a set of n vectors $X_{1t},...,X_{nt}$ with a factor dynamics. The matrix X_t may include in our case, house prices as well as other indicators (GDP, short and long interest rates, prices, housing investment, etc) for a large set of countries.

$$\begin{aligned} X_{it} &= \lambda_i(L)f_t + \varepsilon_{it} \\ \text{where } cov(f_t,\varepsilon_{it}) &= 0 \\ \text{and } cov(\varepsilon_{it},\varepsilon_{jt}) &= 0 \text{ if } i \neq j \end{aligned}$$

The idiosyncratic components ε_{it} may be serially correlated, for example obeying an AR model of order p:

$$\forall i,\ \varepsilon_{it} = \delta_i(L)\varepsilon_{it-1} + v_{it}$$

Transforming the model as following:

$$\begin{aligned}(Id - \delta_i(L)L)X_{it} &= (Id - \delta_i(L)L)\lambda_i(L)f_t + v_{it} \\ &\Longleftrightarrow \widetilde{X_{it}} = \widetilde{\lambda}_i(L)f_t + v_{it} \\ &\Longleftrightarrow X_{it} = \widetilde{\lambda}_i(L)f_t + \delta_i(L)X_{it-1} + v_{it}\end{aligned}$$

allows to get white residuals.
The R factors $f_t = (f_{1t}, ..., f_{Rt})'$ are dynamic factors obeying an AR model too:

$$f_t = \Gamma(L)f_{t-1} + \eta_t$$

Finally,

$$\begin{aligned}X_t &= \widetilde{\Lambda}(L)f_t + D(L)X_{t-1} + v_t \\ D(L) &= \begin{bmatrix} \delta_1(L) & 0 & 0 \\ 0 & . & 0 \\ 0 & 0 & \delta_n(L) \end{bmatrix} \\ \widetilde{\Lambda}(L) &= (\widetilde{\lambda}_1(L), .., \widetilde{\lambda}_n(L))' \\ v_t &= (v_{1t}, ..., v_{nt})' \\ f_t &= \Gamma(L)f_{t-1} + \eta_t \\ \eta_t &= (\eta_{1t}, ..., \eta_{Rt})' \\ \text{avec } \forall i, \forall r, \forall t, \forall s, E(v_{it}\eta_{rs}) &= 0\end{aligned}$$

If $\Gamma(L)$ is a polynomial matrix of order $q-1$, one can define the $\widetilde{R}$- dimensional factor F_t, $R \leq \widetilde{R} \leq Rq$ as:

$$F_t = (f'_t, f'_{t-1}, ..., f'_{t-(q-1)})'$$

such that:

$$\begin{aligned}X_t &= \Lambda F_t + D(L)X_{t-1} + v_t \\ F_t &= \Phi(L)F_{t-1} + G\eta_t\end{aligned}$$

or, equivalently, in a VAR-type framework:

$$\begin{aligned}\begin{bmatrix} F_t \\ X_t \end{bmatrix} &= \begin{bmatrix} \Phi(L) & 0 \\ \Lambda\Phi(L) & D(L) \end{bmatrix} \begin{bmatrix} F_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \xi_{Ft} \\ \xi_{Xt} \end{bmatrix} \\ \text{where } \begin{bmatrix} \xi_{Ft} \\ \xi_{Xt} \end{bmatrix} &= \begin{bmatrix} I \\ \Lambda \end{bmatrix} G\eta_t + \begin{bmatrix} 0 \\ v_t \end{bmatrix}\end{aligned}$$

It is worth emphasizing that the past values of the i^{th} component do not directly influence the dynamics of the j^{th} component ($j \neq i$) because the lag operator $D(L)$ is diagonal.

The influence of the i^{th} component on the j^{th} component ($j \neq i$), if it exists, is indirectly transmitted through the factors.

The previous FAVAR model appears to be a constrained VAR model. It is different from the FAVAR models estimated by Bernanke et al (2004), or Del Negro and Otrok (2005) who do not impose constraints on the autoregressive parameters.

2) The FAVAR model by Bernanke et al. (2004)

The idea underlying the FAVAR models estimated by Bernanke et al.(2004) is the following: if a small number of estimated factors effectively summarize large amounts of information about the economy, then a natural solution to the degrees-of-freedom problem in VAR analyses - which have to be of limited dimensions- is to augment standard VARs with estimated factors.

One considers a $M \times 1$ vector Y_t of observable economic variables of interest, namely in our case, domestic macro variables (GDP, housing prices, short and long interest rates, housing investment, etc) for a given country. One assumes that additional economic information, not fully captured by the Y series, may also be relevant to modeling the dynamics of these series. More preciseley, one assumes that this additional information can be summarized by an $K \times 1$ vector of unobserved factors, F , where K is "small".

The joint dynamics of (Y, F) is given by:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t$$

with v_t denoting a white noise process.

The previous model provides a way of measuring the contribution of the additional information contained in the factors F_t. Besides, if the true system is a FAVAR, the estimation of a VAR model for Y , with the factors omitted, may lead to biased estimates of the VAR coefficients and the associated impulse response coefficients.

The FAVAR model cannot be estimated directly because the factors F_t are unobservable. However, as the factors represent forces that potentially affect many economic variables, one can suppose that it is possible to infer something about the factors from observations on a variety of economic "informational" time series, denoted by a $N \times 1$ vector X_t . This includes house prices in other countries which may affect domestic house prices. The number of informational time series N is "large" , generally assumed to be much greater than the number of factors ($K + M << N$) and the series X_t are related to the unobservable factors F_t and the observable factors Y_t by:

$$X_t' = \Lambda^f F_t' + \Lambda^y Y_t' + e_t'$$

where Λ^f is an $N \times K$ matrix of factor loadings, Λ^y is $N \times M$, and the $N \times 1$ vector of error terms e_t are mean zero and are assumed either weakly correlated or uncorrelated, depending on whether estimation is obtained by principal components or likelihood methods.

Indeed, the model can be estimated in a two-step principal components approach or a single-step Bayesian likelihood approach.

In the two-step procedure, (F_t, Y_t) is estimated using the first $K + M$ principal components of X_t .[1] .

In the second step, a FAVAR model is estimated by standard methods, with F_t replaced by $\widehat{F}_t$. However, to account for the uncertainty in the factor estimation, it is recommended to implement a bootstrap procedure, in order to obtain accurate confidence intervals on the impulse response functions deduced from the FAVAR, except if N is large enough relative to T.

The second approach is a single-step Bayesian likelihood approach, described in details in the appendix of the paper by Bernanke et al. (2004), which refers to Otrok and Whiteman (1998).

Finally, it is worth emphasizing that the factors can be identified so as to be interpreted as a global factor, a country-specific factor or a variable specific factor in the lines of Otrok and Terrones (2004), Del Negro and Otrok (2005) for example, provided that the model is estimated by implementing the one step bayesian approach.

In that case, one postulates that a set of observable variables $(y_{njt}, n = 1, .., N, j = 1, ..., J, t = 1, .., T\ )$, (consisting for example of N macroeconomic series for J countries), depends on a number of latent factors, which capture comovements at the global (F_t^0) or at the national $(F_t^j\ )$ level, or comovements in interest rates (F_t^r) , in house prices,F_t^{HP} a.s.o...., as well as on idiosyncratic shocks $\varepsilon_{n,t}$. Specifically, the model is:

$$y_{njt} = \mu_n + \beta_{0nj} F_t^0 + \sum_{j'=1}^{J} \beta_{nj,j'} F_t^{j'} + \beta_{nj}^r F_t^r + \beta_{nj}^{HP} F_t^{HP} + ... + \varepsilon_{njt}$$

with $\beta_{nj,j'} = 0$ if $j \neq j'$, $\beta_{nj}^r = 0$ if the variable y_{njt} is not an interest rate, $\beta_{nj}^{HP} = 0$, if the variable y_{njt} is not an house price variable and so on.

The law of motions for the factors and the idiosyncratic shocks are given by AR processes:

$$\begin{aligned} F_t^{(k)} &= \sum_{l=1}^{q} \Phi_l^{(k)} F_{t-l}^{(k)} + u_t^{(k)};\ (k) \in \{0, j, r, HP, ...\} \\ & u_t^{(k)} \overset{d}{=} N(0, 1) \end{aligned}$$

and

[1] The estimation of the first step does not exploit the fact that Y_t is observed. However, as shown in Stock and Watson (2002), when N is large and the number of principal components C_t used is at least as large as the true number of factors, the principal components consistently recover the space spanned by both F_t and Y_t . $\widehat{F}_t$ is obtained as the part of the space covered by the components C_t that are not covered by Y_t, tanks to a specific identifying assumption used in the second step.

$$\varepsilon_{nj,t} = \sum_{pl1}^{p} \phi_{nj,l}\varepsilon_{nj,t-l} + u_{nj,t}$$
$$u_{nj,t} \overset{d}{=} N(0, \sigma_{nj}^2)$$

A key identification assumption which allows us to disentangle the factors from one another and from the idiosyncratic shocks is that all innovations are mutually independent.

Thus, at a second step, the latent factors can be included in a FAVAR model. It is worth noting that the bayesian method provides so tightly estimates of the factors that the uncertainty in the estimates of the factors is negligible (Kose et al (2003)) allowing to estimate the FAVAR model like a standard VAR model.

In the following sections, we build on the FAVAR literature by considering a slightly different set of house prices (for 14 OECD countries). We proceed in two steps. First, we extract common factors. We estimate these common factors from our database including house prices only. Following Stock and Watson (2005), we consider that the factors can be written in a VAR format. In a second step, we include our common factors into VAR systems for each country. These FAVAR models are estimated with real house prices in the country, as well as other domestic macroeconomic variables (interest rates, GDP, inflation, etc) and the common house price factors.

3 Data

As indicated before, the analysis concentrates on house prices, but we also used data for the real economy, using OECD quarterly national accounts (households' investment, consumption prices, 3-month and 10-year interest rates), as well as equity prices from BIS. We exclude non residential investment (offices, companies' real estate). For house prices, several database are available, either from the OECD or the BIS. In order to consider a larger (i. e. more recent) sample we rely therefore on national data on house price and checked whether are consistent with the data assembled by the OECD. We use data on Australia, Canada, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Spain, United Kingdom, United States, hence a total of 14 countries[2]. It turned out that they are very close to the OECD for the period starting in 1980. We concentrate therefore on the period from 1980Q1 to 2007Q4. Series were seasonally adjusted. Based on the data for 14 countries, we constructed common factor using Stock&Watson (1999)'s approach, after demeaning and standardising the quarterly growth rates on nominal prices. The common factors are called AXE_1, AXE_2, etc for the first two factors. We also computed two world indeces of nominal house prices, based on a geometric average of national house prices, the first one being unweighted, the second one weighted by the share of the country in world GDP. As indicated in Figure 1 and 2, the first factor is very close from the quarterly growth rate of the unweighted index.

[2] Terrones and Otrok (2004) do not consider France, Germany and Spain, while we exclude Danemark and Sweden, for lack of consistent data.

[PLEASE INSERT FIGURE 1 AND 2 HERE]

4 Modelling approach and empirical results

We proceed in two steps. First we estimate univariate models, then we estimate structural VARs. In both cases, we consider whether the introduction of the common factors have a significant impact on quarter-on-quarter changes in real house prices at the national level.

4.1 Univariate models

Regarding univariate models, we use the General-to-Specific approach, as available in the Grocer software. We first estimate, for each country, a model with the autoregressive component, as well as domestic fundamentals (inflation, GDP growth with an expected positive impact, interest rates with an expected negative impact). We then add the first two common factors and test whether the factors have additional explanatory power. We test alternatively the factor lagged by one quarter or contemporaneously. The results are exhibited in Table 1. In all cases the domestic fundamentals as well as the common factor are introduced with one lag, but the variables that are effectively introduced are based on the results of the General-to-Specific approach. All models end up including fundamentals (usually, at least the interest rate). The only exception is Ireland, where we need to introduce three lags, while the fundamentals are not significant. In addition, the following statistical specification tests, as suggested by Hendry and Krolzig (2001), are implemented in the automatic model selection procedure: Godfrey (1978) Lagrange Multiplier test for serial correlation in the residuals up to 5 lags [LM(5)], Doornik and Hansen (1994) normality test [DH], Nicholls et Pagan (1983) test for quadratic heteroscedasticity between regressors [NP].

Notice that all time series are stationary in growth rates (real house prices, consumption deflator), as clearly indicated from unit root tests. The only exception is for the US, which is a more borderline case since only KPSS tests do not reject I(0) for the growth rate of real house prices.

Table 1 : Country Single Equations

Country	$\Delta Log(p^h_{r,t-1})$	$\Delta Log(i_{t-1})$	$\Delta Log(p_{c,t-1})$	$\text{fac}_{1,t-1}$	$\text{fac}_{2,t-1}$
Australia	0.40(4.36)	-0.19(-3.07)		0.37 (3.27)	
	R2=0.48		D&H=10.06 [0.00]	LM=2.4 [0.05]	NP=2.75 [0.03]
Germany	0.77 (9.07)	-0.26 (-1.73)	0.65 (5.75)		-0.09 (-2.08)
	R2=0.50		D&H=10.29 [0.00]	LM=2.33 [0.38]	NP=2.21 [0.04]
Spain	0.65 (9.57)		1.62 (6.09)		-0.68 (-4.72)
	R2=0.62		D&H=18.37 [0.00]	LM=2.35 [0.15]	NP=3.69 [0.00]
France	0.20 (2.13)	-0.15 (-3.03)		0.16 (1.69)	
	R2=0.22		D&H=27.01 [0.00]	LM=2.38[0.05]	NP=5.86 [0.00]
Ireland	0.04 (0.45)	0.27 (2.90)(*)	0.24 (2.51)(*)	-0.004 (-1.1)	
	R2=0.16		D&H=6.92 [0.01]	LM=1.62[0.68]	NP=1.65 [0.063]
United Kingdom	0.25 (2.55)	-0.17 (-3.55)		0.57 (4.82)	
	R2=0.58		D&H=12.89 [0.00]	LM=1.54 [0.1]	NP=0.84 [0.53]
United States	0.91 (14.37)				0.05 (0.73)
	R2=0.72		D&H=18.43 [0.00]	LM=26.56 [0.00]	NP=7.03 [0.024]

(*) we report here the lagged endogenous variable at t-2 and t-3.

NB: $\Delta Log(p^h_{r,t})$ is the domestic real house pricen interest. $\Delta Log(i_t)$ is the domestic short term nominal interest rate, $\Delta Log(p_{c,t})$ is the quarter-on-quarter domestic inflation rate computed with the consumption deflator. $\text{fac}_{i,t}$ is the ith common factor. Models are selected on the basis of a General-to-Specific approach.

Most models provide a satisfactory fit in terms of R2, except for Ireland. At the 1% level, the autocorrelation of residuals is rejected.

A possible caveat of our approach is that domestic house prices are regressed on common factors that are extracted from a a database which includes, among other the endogenous variable. To assess the robustness of our results, we run the same exercice where factors are computed for each country on a databaseof 13 countries after exclusion of the country. It turns out that the factors are quite close from the previous ones (on the whole database of 14 countries).

Table 2 : Country Single Equations Robustness Checking

Country	$\Delta Log(p^h_{r,t-1})$	$\Delta Log(i_{t-1})$	$\Delta Log(p_{c,t-1})$	$fac_{1,t-1}$	$fac_{2,t-1}$
Australia	0.50 (7.01)	-0.098 (-2.4)			0.22 (2.27)
	R2=0.43		D&H=7.15 [0.02]	LM=1.75 (0.1)	NP=5.36 [0.00]
Germany	0.69 (8.92)	-0.30 (-1.96)	61.96 (5.95)		0.08 (2.19)
	R2=0.46		D&H=12.78 [0.00]	LM=1.48 (0.31)	NP=2.14 [0.06]
Spain	0.43 (5.14)		16.01 (4.46)	0.54 (5.20)	
	R2=0.64		D&H=31.93 [0.00]	LM=1.04 [0.38]	NP=2.96 [0.02]
France	0.39 (4.04)	-0.13 (-2.71)			
	R2=0.29		D&H=21.27 [0.00]	LM=1.46 (0.21)	NP=1.67 [0.16]
Ireland		-0.15 (-2.12)		-0.34 (-1.21)	
	R2=0.10		D&H=7.09 [0.02]	LM=1.45 [0.38]	NP=1.05 [0.22]
United Kingdom	0.40 (4.84)	-0.16 (-3.39)		0.48 (4..44)	
	R2=0.57		D&H=13.16. [0.00]	LM=1.62 [0.17]	NP=0.62 [0.70]
United States	0.89 (15.65)				-0.13 (–1.79)
	R2=0.76		D&H=35.98 [0.00]	LM=0.80 [0.52]	NP=2.15 [0.07]

NB: see Table 1. Models are selected on the basis of a General-to-Specific approach.

It appears that the results change somewhat. In particular the first common factor is replaced by the second common factor in Australia. In addition, The first common factor is now significant in Spain. But the overall conclusion remains, namely that the common factors have explanatory power.

4.2 Favar models

Regarding structural VARs, we estimate Structural FAVAR models by introducing the factor as additional variable in the VAR. We use a Choleski decomposition where the international factor is ranked first, followed by the real domestic house price and the fundamental(s). The variables included as fundamentals are those selected by the General-to-Specific approach. The only difference is that we introduce the real interest rate instead of the nominal interest rate. Four groups of countries may be distinguished:

- UK, Australia and to some extent France, where the first common factor has a signifivant effect, beyond the fundamentals;
- Spain and Germany, which can be explained by domestic fundamentals, or by the second factor, with a negative sign
- The USA which are only explained by domestic fundamentals;
- Ireland cannot be explained by usual fundamentals.

  On the basis of a Favar, there is therefore some partial evidence of the role of common world housing prices in the first group, made of the UK, Australia and France. As indicated in the Annex, the first common factor contribute to the variance of the real house price, although it is much less significant than the autoregressive component and the domestic fundamental. There is also a specific role of the USA housing market, which is not driven by the common housing prices. The case of Ireland should also be investigated further.

5 Conclusion

At this stage, we have investigated the comovements of house prices across industrial countries by extracting factors from these prices. We have examined the contribution of the first factors to the dynamics of the house prices in each country, beside usual observable factors like interest rate, inflation rate or growth rate.

We have observed that a few countries like the United Kingdom, Australia and France are driven by the first common factor of world housing prices.

The next step is to extract factors from a larger dataset including house prices, stock prices, interest rates and macroeconomic aggregates

1) to enrich the caracterization of the comovements of house prices

2) to investigate the relationship between the fluctuations of house prices with the fluctuations of financial asset returns and macroeconomic aggregates.

Accordingly, we plan to follow Kose et al.(2003) and Terrones and Otrok (2004) and estimate a dynamic factor model that contains a global factor capturing comovement in all variables, country specific factors that capture dynamics particular to a country, and aggregate specific factors that capture global movements specific to a variable type (not only house price but also interest rate, stock return, growth rate, a.s;o.).

Thus we will be able to measure the contribution of each factor to the dynamics of each variable included in a well chosen FAVAR model estimated for the main countries.

Moreover, the FAVAR framework can provide information about potential contagion effects.

Indeed, if we observe that a shock into a country-specific variable (interest rate or house price) has an impact on a factor, we can claim that a contagion process is at work, as the factor instantaneously affects all series in all other countries. Another approach is to measure differences in transmission between states, the latter being defined by crisis indicators.

6 References

References

[1] Ben S. Bernanke, Jean Boivin et Piotr Eliasz (2004), "Measuring the efffects of monetary policy:a factor augmented vector autoregressive (FAVAR) approach", *NBER Working Paper* 10220,http://www.nber.org/papers/w10220 and *Quarterly Journal of Economics*, February 2005.

[2] Del Negro, M. and C. Otrok (2007) "99 Luftballons: Monetary Policy and the house price boom across US states" *Journal of Monetary Economics*, 54, 1962-1985.

[3] Goodhart, C. and B. Hofmann (2008) "House prices, money, credit and the macroeconomy", *Oxford Review of Economic Policy*, vol. 24(1), 180-205

[4] Kose, Ayhan, Christopher Otrok, and Charles Whiteman (2003), "International Business Cycles: World, Region, and Country-Specific Factors," *American Economic Review*, Vol. 93 (September),pp.1216–39.

[5] Otrok, Christopher, and Charles Whiteman (1998),"Bayesian Leading Indicators: Measuring and Predicting Economic Conditions in Iowa", *International Economic Review*, Vol. 39, No. 4, pp. 997–1014.

[6] Stock, J.H. and M.W. Watson (2005), "Implications of dynamic factor models for VAR analysis", *NBER*, *Working Paper* n°11467, http://www.nber.org/papers/w11467.

[7] Tatsaronis, K. and H. Zhu (2004) "What drives housing price dynamics: cross-country evidence", *BIS Quarterly Review*, March, 65-78.

[8] Terrones, M. and C. Otrok (2004), "The global house price boom", IMF, *World Economic Outlook*, September.

[9] Vansteenkiste, I and P. Hiebert (2009) "Do house price developments spill over across euro area countries : evidence from a Global VAR", *European Central Bank*, *Working Paper*, 1026.money

Appendix

Figure 1 : world index (weighted) and first common factor

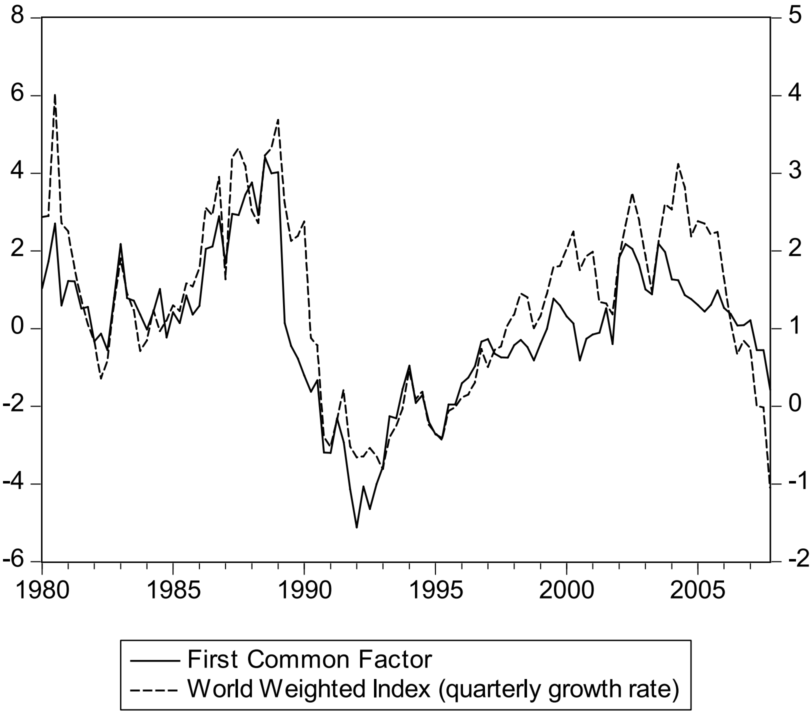

Figure 2 : world index (unweighted) and first common factor

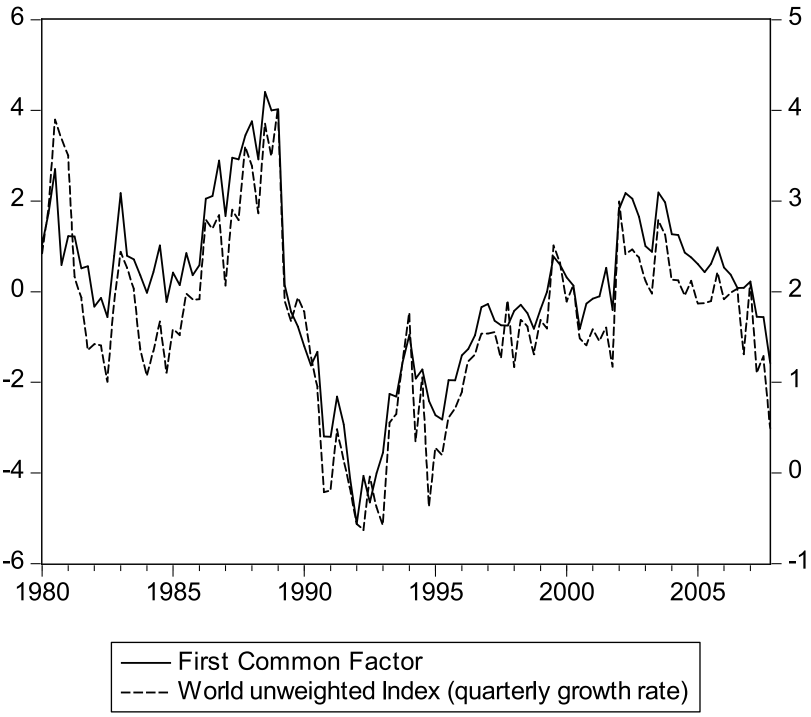

Figure 3 : Favar for Germany

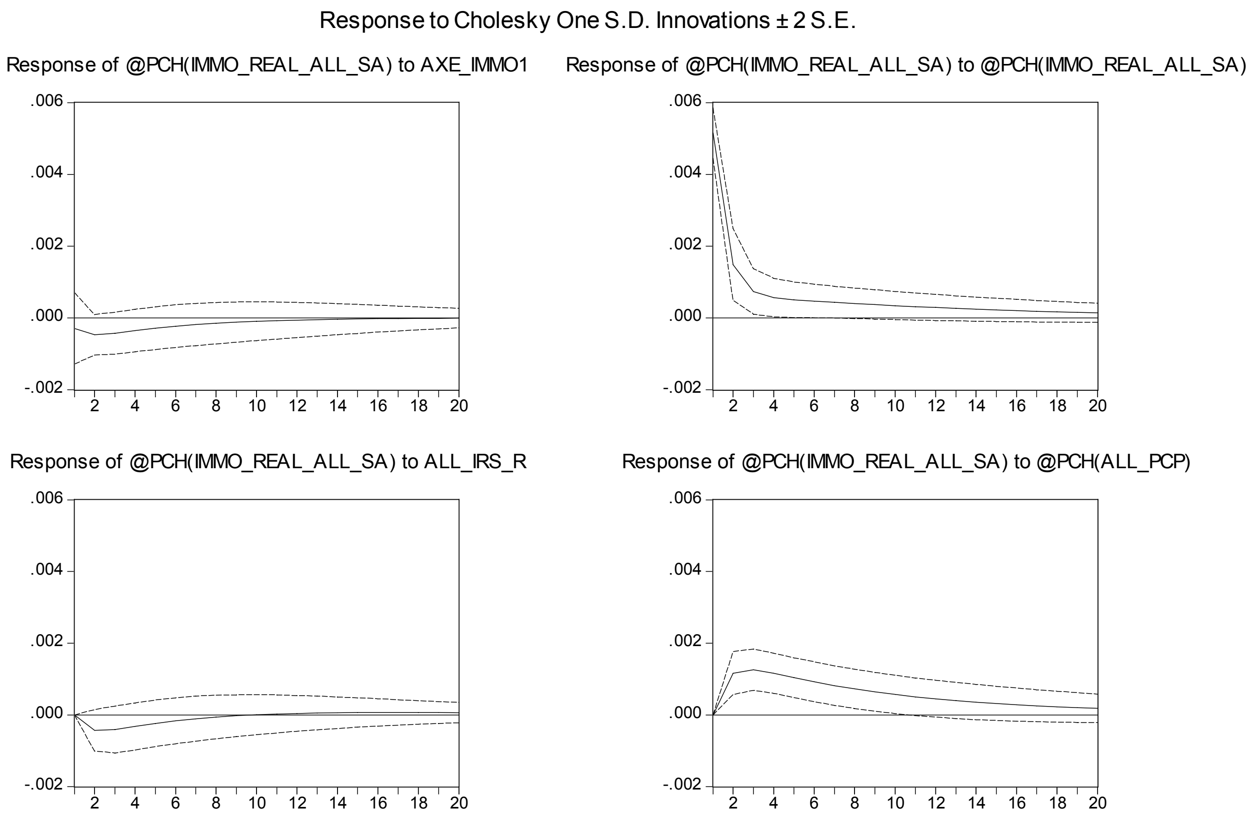

Figure 4 : Favar for Australia

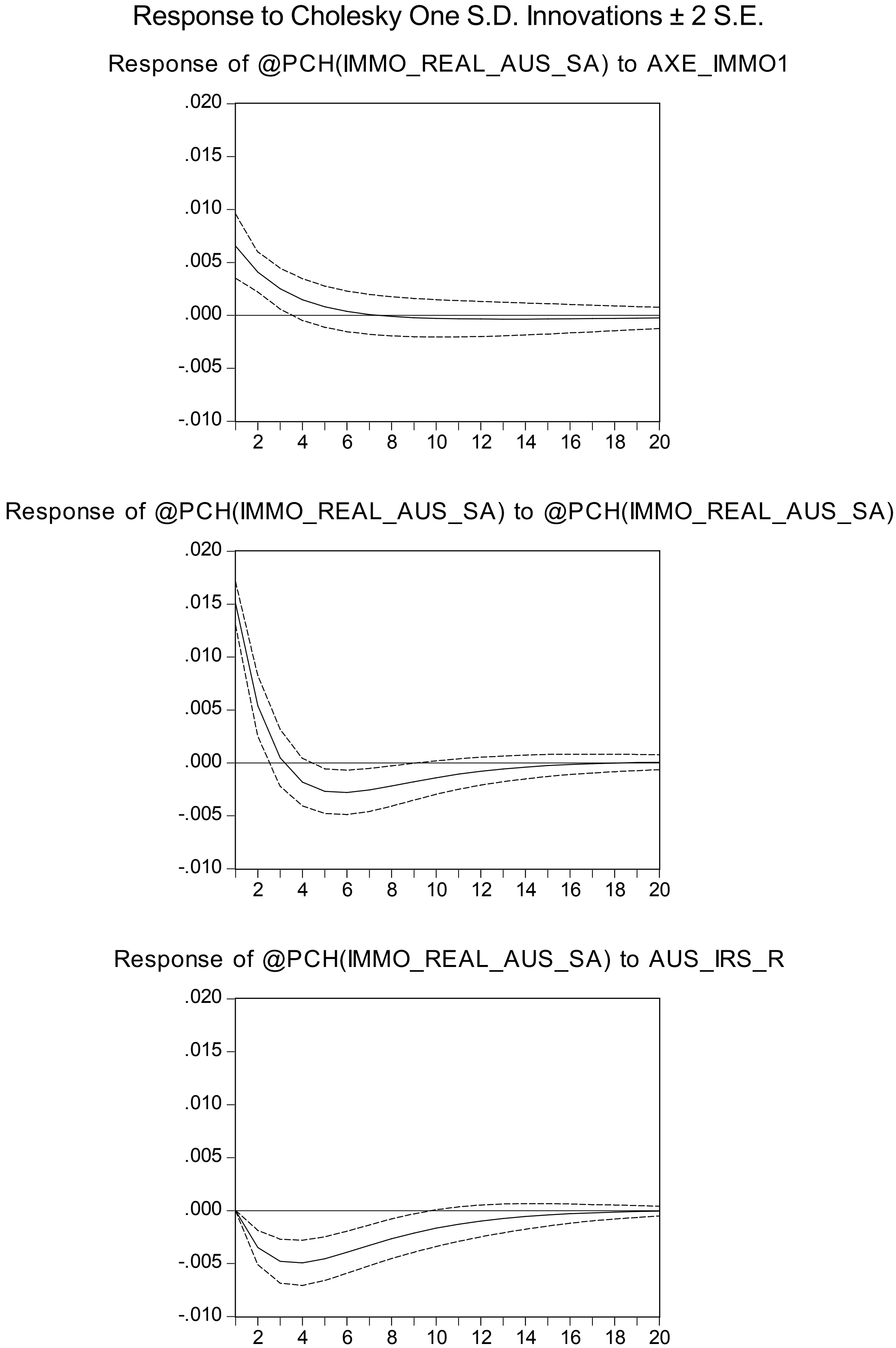

Figure 5 : Favar for France

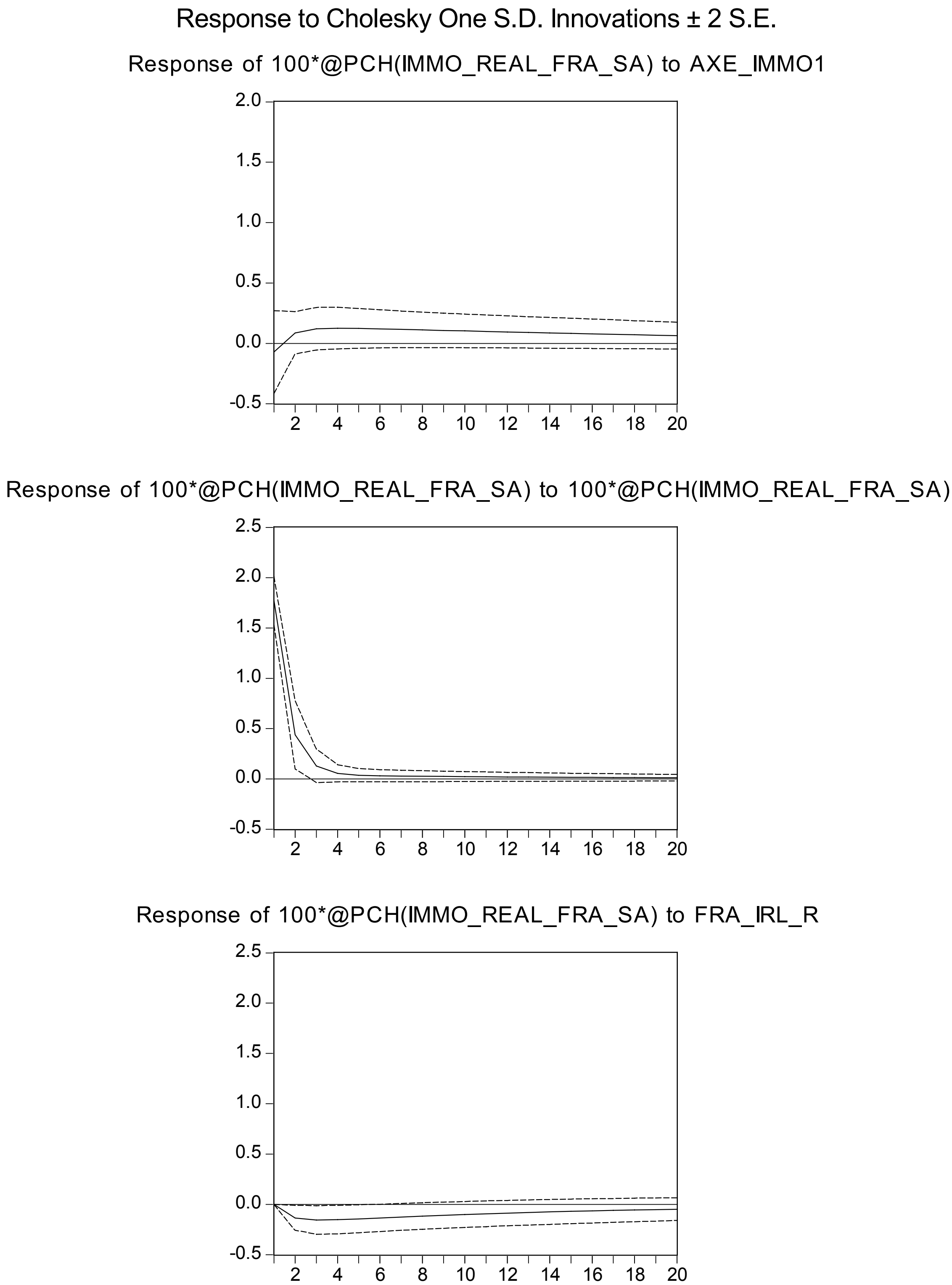

Figure 6: Favar for Ireland

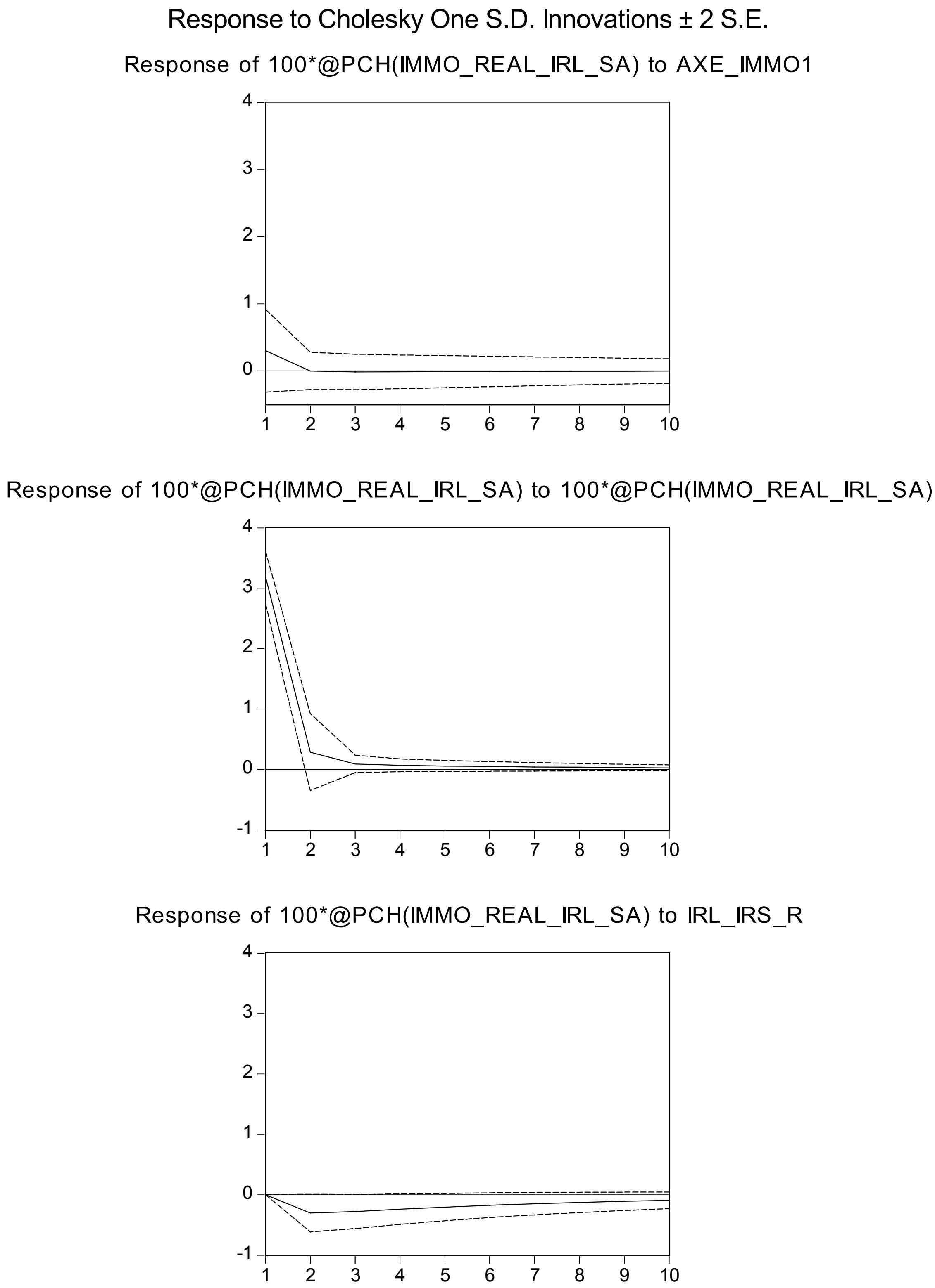

Figure 7 Favar for United Kingdom

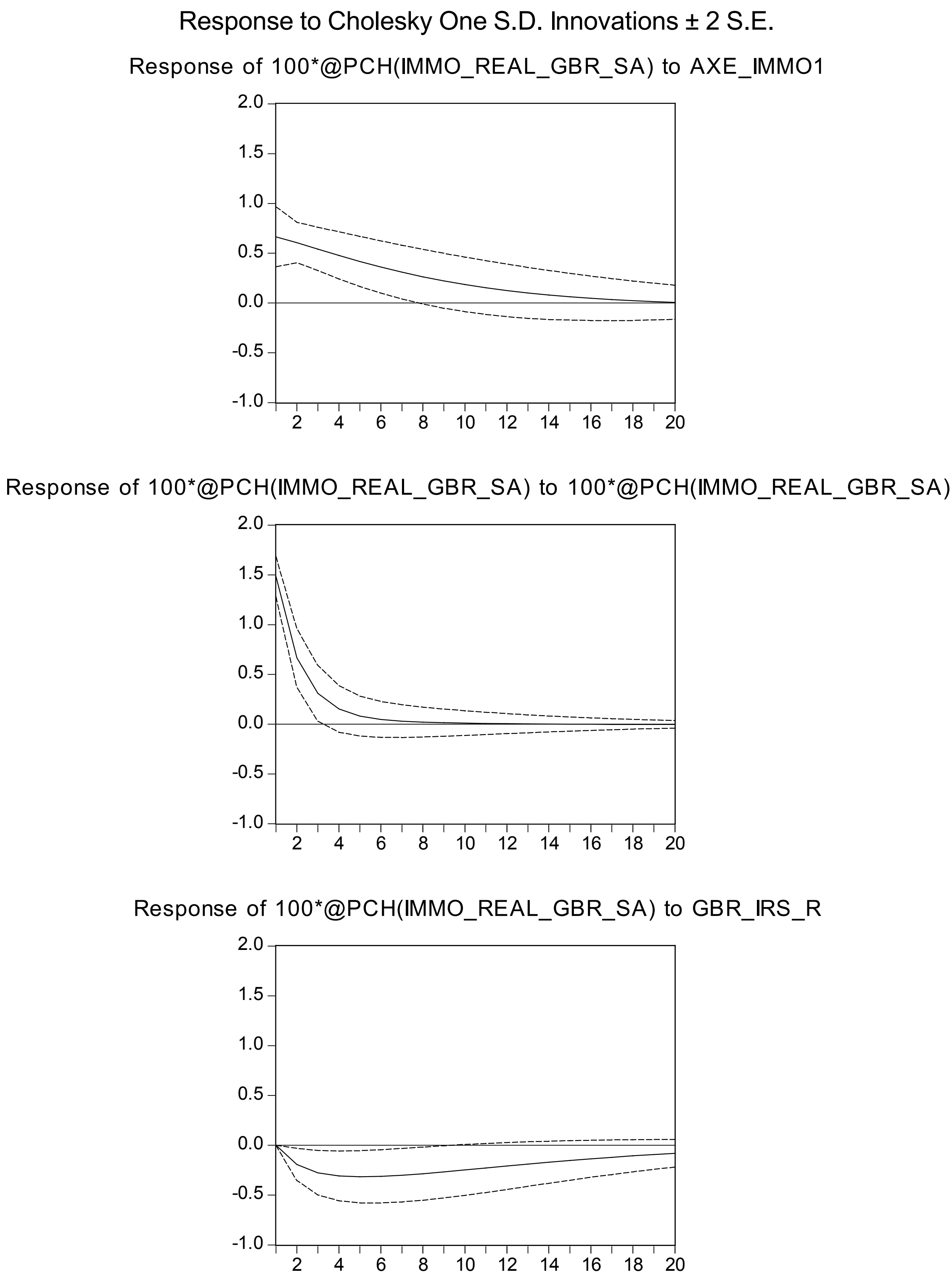

Figure 8 : Favar for United States