
House Price Comovements in the Eurozone Economies

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Abstract:

The house price boom in major industrialized countries since the early 1990s has been unprecedented. Co-movement is a key feature of it and it has been attributed by scholars to synchronization of monetary policy, financial liberalization, integration of international financial markets, as well as global business cycle linkages. In this paper we focus on seven European countries, all members of the EMU, and ask the question if, the apparent co movement of the housing prices in the seven major euro zone economies implies convergence of their housing markets. Using monthly data from DSI Statistical Bases for 1990(1)-2009(4), we concentrate on the impact of the adoption of the common currency on real house prices movements. We conduct the analysis using country-specific macroeconomic variables and then extend it by adding foreign-specific macro variables to each country's model. The empirical analysis includes cointegration analysis and VAR specifications. Our findings suggest that the movement of the housing prices of the euro zone countries apart from the well known fundamentals of GDP, interest rates and stock returns is also based on a number of idiosyncratic and structural factors like demographics, the tax system and government intervention which determine the duration and the strength of the housing cycles in each country. Furthermore, it seems that the degree of convergence underlying housing prices co movement is limited given the diversities in living standards, regulation of property markets, government intervention and attitudes to residential housing.

Key Words: House Prices, Comovement, Eurozone

JEL Classification: C31, D46, G12

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1. Introduction

International transmission of house price changes appears to be a natural corollary of an increasingly internationalized and interdependent financial environment. In addition, parallel movements in borrowing conditions and macro-economic fundamentals are expected to strengthen the tendency of international house prices to comove. This should be particularly true in the case of the euro-zone, where the currency is common and monetary policy is conducted by the European Central Bank on behalf of all members. Since the mid-1990s, in particular, the housing prices of major European economies have been strongly increasing and this increase has been largely associated with high growth rates experienced over the last decade. However, recently such comovement has been blamed for triggering the latest global financial crisis.

Housing as a non-traded good is not easily substituted among different countries. Over the last decade it has been claimed that major European countries' housing markets have been overvalued and that housing spillover effects appeared not only within an economy but also across economies.

Two main differences stand out in the behavior of real assets like residential housing as opposed to financial markets assets like shares and bonds. First it is possible to use the information included in housing prices to make returns in excess of a buy and hold strategy i.e the efficient market hypothesis does not hold and second the housing prices are less flexible downwards compared with stocks. So the risk-return profile of an asset like residential housing makes it more attractive to investors.

This paper sets out to investigate the factors underlying the apparent comovement of housing prices of the largest Euro zone economies. Specifically, we will examine first the relative importance of local factors (income, interest and stock prices) in explaining house price movements on a national level. Doing that, we differentiate between pre- and post-Euro periods and distinguish between economic expansions and contractions. We then look at the existence of spillover effects of shocks from both German monetary policy and volatility in its home housing market to the real house prices of the other countries in the Euro zone. Finally, we investigate the impact of global shocks such as emanating from changes in the US monetary policy on the volatility of each country's housing market.

Using monthly data from DSI Statistical Bases for 1990(1)-2009(4), we investigate first whether there is overvaluation in real house prices across seven Euro zone economies. The economies examined namely Austria, Finland, France, Germany, Italy, the Netherlands, and Spain, constitute the core of the Euro zone, and are responsible for 90% of the zone's GDP and making up the second largest economy in the world after the US. Next, we concentrate on the impact of the adoption of the common currency on real house prices movements. We conduct the analysis using country-specific macroeconomic variables and then extend it by

adding foreign-specific macro variables to each country's model. The empirical analysis includes cointegration analysis and VAR specifications.

The rest of the paper is organized as follows: A brief survey of related literature is conducted in section 2. Section 3 presents stylized facts from each country's housing market. Section 4 outlines the methodology employed in the paper and includes the data description and variable selection. Section 5 presents and discusses the empirical findings. Concluding remarks are made in section 6.

2. Review of the Literature

A number of studies have indicated comovement of house price changes, mainly attributed to synchronization of monetary policy, financial liberalization, integration of international financial markets, as well as global business cycle linkages (see, for example, Helbling and Terrones, 2003; Tsatsaronis and Zhu, 2004; Scanlon et al., 2008; Kim and Renaud, 2009).

Goetzman and Wachter (1996) found that international real estate investors were exposed to common risk due to what appeared to be a global GDP effect, while a study by Case et al. (2000) concluded that price changes in real estate markets around the world were surprisingly correlated, possibly owing to a common exposure to world economic conditions. McAllister (1999) found that lower international integration levels in real estate, mainly due to high information costs, makes property more segregated than other asset classes, thus pointing to potential international diversification benefits. More recently, Hilbers et al. (2008) showed that house prices in Europe have exhibited diverging trends, attributing differences to the different causes of price movements (income and user costs versus ample supply, low home ownership and less complete mortgage markets) in different countries.

Vansteenkiste (2007) examined regional house price spillovers across United States and noted that house price spillovers existed and were particularly important in regions with low land supply elasticity. Klyuev (2008) argued that from the early 1990s onwards changes in regional home prices in the United States have been more synchronised than before, suggesting a common national housing market expansion and subsequent correction. Similarly, Vansteenkiste and Hiebert (2009) concluded that there are limited spillovers of house price changes across euro-zone countries.

Otrok and Terrones (2004, 2005) conducted a systematic analysis of house prices across developed countries and verified the large degree of synchronization in the growth rate of real house prices amongst these countries. They attributed the comovement to a common dynamic component in interest rates across these countries. Their results were also confirmed by DeBandt et al. (2009) who found evidence of international transmission of housing prices across large industrialized countries.

This study attempts to show that despite the co movement observed in the housing prices of the seven major euro zone countries, convergence in their housing markets has not been achieved, instead it is rather weak and it is likely to remain so for the foreseeable future.

3. Assessing Housing Market Conditions in the Eurozone

One commonly used measure to assess housing market conditions is the price to income ratio. If this ratio is above its long term average (mean of the time series) it is an indication that prices are overvalued and housing cannot be easily afforded by the average buyer. Figure 1 shows the ratio of real house prices to per capita disposable income and for almost all countries, with the exception of Germany, this ratio is above its long term average for a long period of time. In this case prospective buyers would find purchasing a home difficult, which in turn would reduce demand and lead to downward pressure on house prices and return to long run levels. That would have been the case if this upswing in housing prices across Europe was not accommodated by expansionary monetary policy which prolonged the overvaluation in the euro zone countries housing markets.

More specifically, in Austria the house price boom after 2005 was mainly due to low interest rates, mortgage market expansion and strong economic growth. Austria's mortgage market is small compared to other EU countries. Outstanding housing loans rose from 14% of GDP in 2001 to 25% of GDP in 2008. The average mortgage market size in the EU is 50% of GDP. Vienna has one of the highest percentages of renter households in the world, at 77.2% in 2007, while the figure for Austria as a whole is around 58%. Around half of the rental stock in Vienna and Austria is privately owned. Its long run average price to income ratio is 0.395 and as can be observed from Figure 1, since 1996 housing prices in Austria seem to be overvalued.

Finland has traditionally had a very cyclical economy, highly exposed to world markets, and sensitive to global shocks. A major driver of Finland's GDP growth is Nokia, the country's largest company, and the single most significant cause of the country's success. Finland's house price boom lasted from 2001 to 2008:II. The upsurge in house prices was mainly due to strong economic and wage growth, changes in the mortgage market, combined with low interest rates, which made housing more affordable for all income brackets. To this effect the tax system also contributed. Outstanding housing loans to Finnish households grew 153% from 18.4% of GDP to 36.3% of GDP. Owner-occupation is still privileged by the tax system, for despite reforms during the 1980s, a flat 29% tax deduction on mortgage interest remains in place, while imputed rental income and capital gains on permanent homes are untaxed.

The relative volatility of house prices in Finland is mainly due to the export-oriented economy's sensitivity to global shocks; the housing market's high interest

rate sensitivity; and an insufficiently responsive supply side. Its long run average price to income ratio is 0.428 and as can be observed from Figure 2, since 2005 housing prices in Finland seem to be overvalued.

Germany remains the world's most stable housing market. A serious problem is that Germany's population has been shrinking since 2002, by an average of 50,000 persons per year. Home-buyers in Germany mostly borrow at a fixed rate, which helps keep the market stable, and not subject to booms and busts. Germany's mortgage market is Europe's second largest in monetary terms, after the UK. However, mortgage growth has been sluggish since 2000. As a percentage of the GDP, outstanding housing loans rose from 30% in 1991 to 50% in 2000. By 2007, they were back to 45% of GDP. Most Germans live in rented accommodation. Although the proportion of renters to total households slightly slid from 58% in 1990, to 55% in 2004, this rate is still among the highest in the world. Private landlords own about 46% of the housing stock, social housing is around 6%, and co-operative rentals are around 6%. Rent increases have outpaced real estate prices since 2000, leading to slightly higher yields. Its long run average price to income ratio is 0.381 and as can be observed from Figure 1, since 2004 housing prices in Germany seem to be undervalued.

Italy's housing market has remained resilient, despite falling markets in most other developed countries. House prices in the first quarter of 2009 rose by 3% from a year earlier. The resilience of Italy's housing market is attributable to what was formerly considered a weakness, its underdeveloped mortgage market. Despite having the fourth largest economy in the EU, Italy's mortgage market is around 20% of GDP, significantly below the EU average of 50% of GDP. Italy's housing market has been shielded from the global credit crunch afflicting most countries. Prudent loan practices prevented the development of housing bubbles similar to Spain, Ireland or the UK. One of the main reasons for the underdevelopment of the mortgage market is the length and cost of the loan recovery process. While house prices rose by an average of 6.3% from 2000 to 2008, rents rose by an average of only 2.5% over the same period. Its long run average price to income ratio is 0.38 and as can be observed from Figure 1, since 1997 housing prices in Italy seem to be overvalued.

The Netherlands has enjoyed a house price boom which lasted from 1992 to 2007. At the peak of the boom, prices rose by an average of 11% (8.4% in real terms) annually from 1996-2001. Since the 1980s, the government has aggressively promoted homeownership by offering generous mortgage subsidies. The Dutch mortgage market has expanded rapidly over the past decade, with residential mortgage debt rising to almost 100% of GDP in 2008, up from 60% of GDP in 1998. Owner-occupancy is around 55% of the occupied stock (2005 figure), up from 42% in 1980. Strong economic growth and falling interest were primarily the reasons for this boom. Its long run average price to income ratio is 0.08 and as can be observed from since Figure 1, 1995 housing prices in the Netherlands seem to be overvalued.

In Spain rapid economic growth and foreign purchases, were the main drivers of the house price boom. Foreign investment in property dropped by 20.8% between 2008-2009. As a percent of GDP, it slipped to 41%, from 52%, over the same period. Real interest rates are negative as Spaniards traditionally did not finance house-purchases through mortgages. But the liberalization of the mortgage market in the 1990s, combined with a drastic reduction in mortgage interest rates, changed all that. In proportion to GDP, mortgages outstanding rose from 17% of GDP in 1995, to more than 61% by end of 2008. The construction industry is a key driver of the Spanish economy. Construction activity helped push unemployment down to 7.95% in Q2 2007, from 24% in 1994. Spain's economy expanded by an average of 3.6% from 2000 to 2007. Its long run average price to income ratio is 0.363 and as can be observed from Figure 1, since 1997 housing prices in Spain seem to be overvalued.

In France economic growth and house price increases tend to move together, but at significantly different paces. For instance, when house prices rose by an average of 7% annually from 2001 to 2007, the economy expanded by a mere 1.8% annually. In 2008, France's GDP grew by 0.7%, while house prices fell by an average of 3%. The private rental market comprises about 21% of the housing stock while 17% belongs to the social rental market. The owner-occupancy rate has slightly risen, from about 54% in 1996 to about 56% in 2008. Government subsidies are one reason for the resilience of France's housing market. Housing subsidies amounted to €34 billion, or 2% of GDP, in 2008. About 40% of new housing in France receives some sort of subsidy. Its long run average price to income ratio is 0.384 and as can be observed from Figure 1, since 2001 housing prices in Spain seem to be overvalued.

Overall it is apparent that the movement of the housing prices of the euro zone countries apart from the well known fundamentals of GDP, interest rates and stock returns is also based on a number of idiosyncratic and structural factors like demographics, the tax system and government intervention which determine the duration and the strength of the housing cycles in each country. Furthermore, it seems that the degree of convergence underlying housing prices co movement will be limited given the diversities in living standards, regulation of property markets, government intervention and attitudes to residential housing.

4. Methodology

In this section, we conduct the preliminary statistical investigation and present the VAR methodology briefly. More specifically, subsection 4.1 contains the unit-root tests, to detect variable stationarity or not, using the Kwiatkowski et al. (1992) methodology. Subsection 4.2 presents the cointegration test results among the variables employing the Johansen (2005) methodology and subsection 4.3 contains some results from simple correlation analyses. The five main variables

under examination are the housing price index (*hpi*), consumer price index (*cpi*), gross domestic product or GDP (*y*), long-term interest rate (*ltr*) and stock prices (*sp*) for each country. We also used the disposable income variable as a substitute for the country's GDP but did not show any qualitative change in the subsequent empirical results. The sample is from January 1990 to April 2010. Both cointegration and correlation analyses will be done in two subperiods, 1990:01 to 1999:12 and 2000:01 to 2010:04, in order to see if the Euro introduction year (1999) had any impact on the relationships among the five variables.

4.1 Unit Root Analysis

We begin the preliminary statistical analysis with a test for variable stationarity. The standard KPSS unit-root methodology specifies the null hypothesis as of a variable being stationary against the alternative of non-stationarity. In performing these tests, we used several lags and a time trend, but the results basically remained robust. The critical value, at the conventional 5% level, is 0.4630. The results are shown in Table 1. The results indicate that all series contain a unit root in their level (log) form but become stationary after being differenced once. Exceptions to becoming stationary after having been differenced once are Germany's housing price index (*hpi*) and consumer price index (*cpi*), which needed to be differenced twice.

Table 1. Unit root test results

Variable	Country						
	AUSTRIA	FINLAND	FRANCE	GERMANY	ITALY	NETHERLANDS	SPAIN
<i>hpi</i>	1.9336	1.736	1.9380	1.7172	1.9435	1.9711	1.9656
<i>dhpi</i>	0.1547	0.185	0.1275	0.5000†	0.4630	0.3373	0.1043
<i>cpi</i>	1.9560	1.945	1.9549	1.9078	1.9544	1.9746	1.9596
<i>dcpi</i>	0.1404	0.1354	0.1032	0.4858†	0.3413	0.0805	0.2367
<i>y</i>	2.0401	0.8598	1.9496	1.8838	1.8631	1.9276	1.9433
<i>dy</i>	0.0998	0.3232	0.2614	0.1345	0.3137	0.4134	0.1911
<i>ltr</i>	1.7312	1.6448	1.6803	1.7432	1.6546	1.6836	1.6703
<i>dltr</i>	0.0441	0.1299	0.0883	0.0435	0.1387	0.0503	0.1953
<i>str</i>	1.3036	1.4899	1.6091	1.2721	1.8507	1.2897	1.7936
<i>dstr</i>	0.1945	0.0850	0.0753	0.2278	0.0675	0.1795	0.0711
<i>sp</i>	1.8670	1.7783	1.7441	1.7348	1.8874	1.7664	1.8871
<i>dsp</i>	0.2344	0.2114	0.2102	0.2458	0.3343	0.2815	0.2890

Notes: *hpi* denotes the housing price index; *cpi* denotes the consumer price index; *y* is the disposable income; *ltr* is the long-term interest rate; *str* is the short-term interest rate; *sp* are stock prices; *dhpi* denotes change in the variable; the unit-root regressions contained a constant term; † denotes second difference; critical values at the 1% and 5% levels are 0.7390 and 0.4630, respectively.

In view of the above results on the order of integration of each series, we proceed next to check for cointegration among the main series.

4.2 Cointegration analysis

In order to examine the long-run properties of the five main series, we will apply the Johansen (1995) cointegration methodology because of its good (finite-sample) properties. Without getting into the details of the test, it suffices to state that it involves the estimation of the series' residuals from the following regressions:

$$\Delta Y_t = \mu_1 + \sum_{i=1}^{k-1} \Gamma \Delta Y_{t-i} + \varepsilon_{1t} \quad (1a)$$

and

$$Y_{t-k} = \mu_2 + \sum_{i=1}^{k-1} \Gamma \Delta Y_{t-i} + \varepsilon_{2t} \quad (1b)$$

where $Y_t = (hpi, y, cpi, ltr, sp)'$, hpi is the (log of) housing price index, y is the (log of) GDP, cpi is the (log of) consumer price index, ltr the long-term interest rate and sp (the log of) stock prices, μ_1 and μ_2 are constant vectors, and Δ is the change in a variable. The methodology computes two statistics, the trace and the maximum eigenvalue. The trace statistic is given by

$$t_r = -T \sum_{j=r+1}^n \ln(1 - \lambda_j), \quad 0 \leq r \leq n \quad (2a)$$

and tests the hypothesis that there are at most r cointegrating vectors. When testing the hypothesis of r against the alternative of $r + 1$ cointegrating vectors, we use the max-eigenvalue statistic, given by

$$\lambda_{r|r+1} = -T \ln(1 - \lambda_{r+1}) \quad (2b)$$

where the eigenvectors (u_1, \dots, u_r) are sample estimates of the cointegrating vectors above.

The results from the two statistics are shown in Table 2 for the two subperiods. From the table, we observe various degrees of integration for each country and each subperiod based on the trace test. In both subperiods, we observe weak cointegrating relationships among the five variables for each country. In some cases like for France, we see at least one cointegrating relationship, while for the other countries we see several ones (see for instance the case of Austria where we see up to four such relationships). A similar picture is evident for the second subperiod for all countries. At times, the trace and max eigenvalue statistics values

contradict each other, in terms of how many significant cointegrating relationships exist, like in the case of Spain. A cursory interpretation of these results might be that the effect of EMU was not strong in harmonizing the housing markets in the Euro zone and perhaps other factors, foreign and/or local, may be responsible for such heterogeneity. In any event, we need to explicitly model these long-run relationships among the variables within a vector autoregression (VAR) model, which we do in section 5.

Table 2. Multivariate cointegration test results

Country/ No. of CEs	Pre-Euro Period (1990:01 – 1999:12)		Post-Euro Period (2000:1–2010:04)	
Austria	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None*	111.25	44.61	103.61	49.35
At most 1**	66.63	34.27	54.27	21.59
At most 2*	32.37	14.23	32.65	19.15
At most 3*	18.12	11.06	13.51	7.83
At most 4**	7.06	7.06	5.68	5.68
Finland	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None*	112.92*	44.34	128.74	60.43
At most 1**	68.59	29.72	68.31	28.67
At most 2**	38.86	24.57	39.63	25.85
At most 3	14.28	12.38	13.78	11.78
At most 4	1.90	1.90	1.99	1.99
France	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None**	119.42	58.11	78.18	30.69
At most 1*	61.31	40.08	47.49	23.49
At most 2	21.22	14.64	24.00	15.64
At most 3	6.58	6.58	8.37	7.59
At most 4	0.00	0.00	0.76	0.76
Germany	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None**	185.33	94.81	70.13	32.19
At most 1**	90.51	47.32	37.97	20.82
At most 2**	43.18	27.27	17.14	10.96
At most 3*	15.91	14.48	6.18	4.71
At most 4	1.42	1.42	1.46	1.46

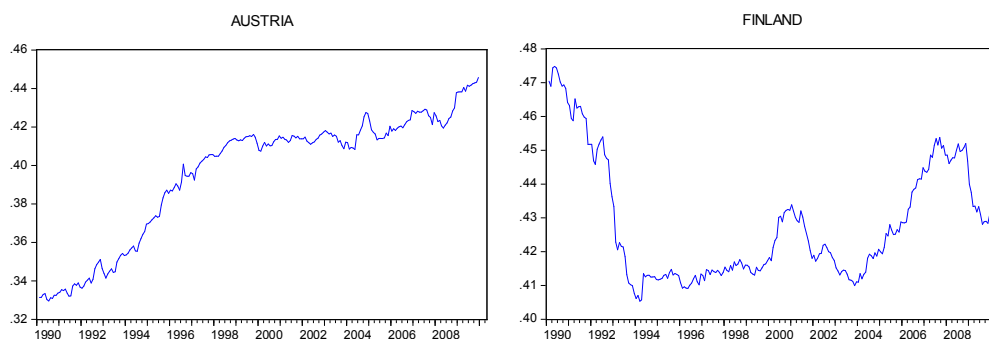
Table 2. Multivariate cointegration test results (concl'd)

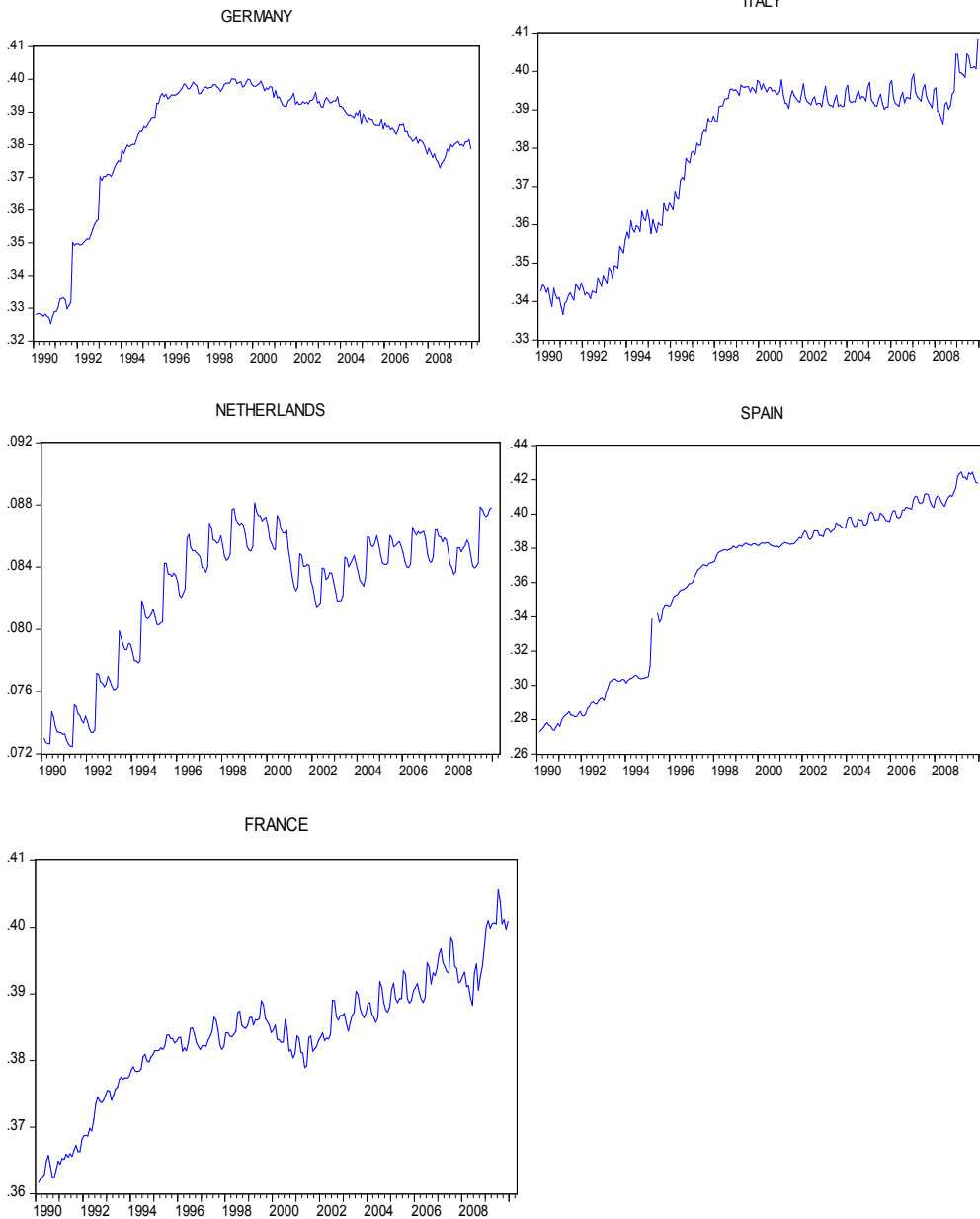
Country/ No. of CEs	Pre-Euro Period (1990:1–1999:12)		Post-Euro Period (2000:1–2010:04)	
Italy				
	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None**	145.35	56.20	111.33	40.38
At most 1**	89.14	34.63	70.95	32.52
At most 2**	54.50	28.28	38.42	21.52
At most 3**	26.22	19.10	16.90	10.11
At most 4	7.11	7.11	6.79	6.79
Netherlands				
	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None*	144.64	83.07	171.76	60.00
At most 1*	61.56	24.72	111.76	51.31
At most 2*	36.84	19.16	60.45	41.03
At most 3	17.67	11.23	19.41	16.08
At most 4	6.43	6.43	3.33	3.33
Spain				
	Trace	Max Eigenvalue	Trace	Max Eigenvalue
None**	104.69	44.66	143.48	77.89
At most 1**	60.03	26.62	65.59	33.34
At most 2*	33.41	14.26	32.25	17.78
At most 3	19.14	13.47	14.47	13.36
At most 4	5.66	5.66	1.11	1.11

Notes: Osterwald-Lenum critical values, at the 5% level, for the trace statistics are 68.52, 47.21, 29.68, 15.41, and 3.76, and for the max eigenvalue statistics 33.46, 27.07, 20.97, 14.07, and 3.76, for each cointegrating equation (CE); in regressions the assumption of a linear deterministic trend was used.

** denotes co-integration was found

Figure 1. Ratio of Real House Prices to per Capita Disposable Income, 1990:01 - 2010:04.





4.3 Correlation analysis

Table 3 displays the simple correlations among the housing price index variable for each country for the two subperiods. The numbers below the diagonal correspond to the pre-Euro sub period while those above the diagonal correspond to

the post-Euro sub period. Inspecting the pre-Euro sub period correlations we see that the lowest pair wise correlations are those between Germany's and Finland's housing indexes (0.0898) and between Austria's and Finland's indexes (0.2864). The highest index correlations are seen for the Germany-Austria pair (0.9986) and Austria-Italy or Italy-Spain pairs (0.9970). In the post-Euro sub period, we observe very high pair wise housing index correlations, ranging from 0.8880, between Finland and the Netherlands, to 0.9983, between the Netherlands and Italy or Germany and Italy.

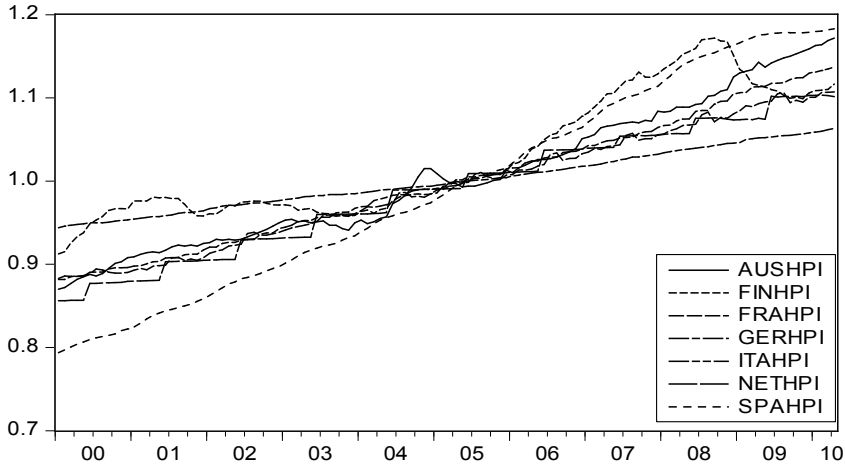
Table 3. Correlations among House Price Indexes

	Austria	Finland	France	Germany	Italy	Netherlands	Spain
Austria		0.9150	0.9830	0.9910	0.9907	0.9721	0.9855
Finland	0.2864		0.9040	0.9127	0.9026	0.8880	0.9255
France	0.9854	0.1897		0.9954	0.9962	0.9932	0.9970
Germany	0.9686	0.0898	0.9924		0.9983	0.9865	0.9966
Italy	0.9970	0.3204	0.9767	0.9598		0.9883	0.9960
Nether.	0.9937	0.3067	0.9828	0.9639	0.9946		0.9900
Spain	0.9944	0.3105	0.9841	0.9848	0.9970	0.9941	

Notes: the below-diagonal figures refer to the pre-Euro subperiod (1990:01 – 1999:12), while the above-diagonal ones to the post-Euro subperiod (2000:01 – 2010:04).

Figure 2 depicts the housing indexes of all countries for the entire sample period, 1990:01 to 2010:04. We see that there is higher co movement among them in the post-Euro sub period (the 2005 is the indexes' base year) despite Germany's index rather flat path and Spain's steeper index path. Another interesting observation is Finland's index path, which is seen to fluctuate throughout the sample period. The index paths of the remaining countries appear to follow a similar, upward trend in either sub period. However, these are simple measures of co movement among these indexes; a more robust approach is needed to uncover the true relationships among them. Such an approach is undertaken next.

Figure 2. Country House Price Indexes, 1990:1 – 2010:4



4.4 The VAR methodology

Since the task here is to estimate the empirical relationship(s) among the main five variables (housing prices, interest rates, inflation, disposable income and stock prices), while placing as few theoretical restrictions as possible on the system’s variables, we will use the vector autoregression (VAR) framework. VARs are attractive for three reasons. First, they impose very few a priori restrictions on explanatory variables or on the model’s lag structure and this offers good protection from econometric problems in order to achieve identification. Second, the variables in a VAR model permit an efficient estimation over shorter periods of time, compared to large-scale structural models. And third, unrestricted VAR models examine the impact of a shock by investigating its implication on (the innovation of) a variable rather than its predictable component. Thus VARs constitute a powerful vehicle for investigating shock-transmission mechanisms or variable feedbacks.

More generally, a VAR involves regressing an $n \times 1$ vector of endogenous variables, y_t , on lagged values of itself as follows:

$$y_t = \Xi_1 y_{t-1} + \Xi_2 y_{t-2} + \dots + \Xi_p y_{t-p} + e_t, \quad E(e_t e_t') = \Omega \quad (3)$$

Assuming that y_t is covariance stationary, then the above equation can be inverted and represented by an (infinite) vector moving average process as follows:

$$y_t = e_t + \Pi_1 e_{t-1} + \Pi_2 e_{t-2} + \dots \quad (4)$$

Given that the variance-covariance matrix of e_t (Ω) is positive definite and symmetric, the Choleski factorization means that there exists a lower triangular matrix P such that $\Omega = PP'$. Using P , equation (3) can be rewritten as:

$$\begin{aligned}
 y_t &= PP^{-1}e_t + \Pi_1 PP^{-1}e_{t-1} + \Pi_2 PP^{-1}e_{t-2} + \dots \\
 &= \Gamma_0 u_t + \Gamma_1 u_{t-1} + \Gamma_2 u_{t-2} + \dots
 \end{aligned}
 \tag{5}$$

where $\Gamma_i = \Pi_i P$, $u_t = P^{-1}e_t$, and $E(u_t u_t') = I$. So, equation (3) represents the endogenous variables as a function of the orthogonalized innovations (u_{t-i}).

If the above estimated coefficients are jointly found to be statistically significant, then past values of a given variable can explain variations in the other variable and the null hypothesis can be rejected. Finally, since determining the optimal lag structure of equation (4) is a concern that needs to be addressed, for if the lag structure is mis-specified the empirical results may be biased, the use of Akaike's (1976) Final Prediction Error (FPE) criterion will be employed.

5. Main Empirical Results

In this section, we present the main empirical results from the VAR models for each country and each sub period. We conduct the analysis using country-specific macroeconomic variables first and then extend it by adding foreign-specific macro variables to each country's model. In all cases, the variables examined are in real terms. For the sake of space preservation, we present only the impulse response functions (graphs). The regression results are available upon request.

Given that VAR models are *theoretical*, it would be difficult to specify a priori the natural order of variables making up the VAR system based on the assumed underlying economic theory. This means, that we need to solve the problem of establishing a reasonable variable ordering and imposing the Choleski orthogonalization of shocks. Obviously, these issues become severe when one deals with multivariable VAR systems like one in this paper. A way to get around these problems is to compute the generalized forecast errors or generalized forecast error variance decompositions (GFEVDs) and the generalized impulse response functions (GIRFs). This technique is due to Koop *et al.* (1996) and Pesaran and Shin (1998) who proposed computing the GFEVDs and GIRFs for unrestricted VAR systems.

The computation of the GFEVDs allows for robust comparisons about the information content of a shock of one variable to another. Moreover, the GFEVDs of each variable measure the extent of the initial impacts on the other variables. The latter can be interpreted as the amount of relative information contained in that variable as it affects another over time. Similarly, the interpretation of the GIRFs is that they simply describe the dynamics of a series by tracing its reaction to (a one unit standard deviation) shock to the residuals in its equation. In other words, a variable's response describes the effect of shocks that have been historically observed (as described by the sample covariance matrix).

5.1 Assessing the impact of local factors on real house prices

Figure 3 shows selected generalized impulse responses of each country's real house prices to shocks from the other domestic variables, namely real GDP growth, long-term interest rate and real stock returns. In general, we observe the following. As regards the shocks from GDP growth, real house prices initially react both positively (as in the cases of Finland and Germany) and negatively (as in the cases of Austria and Spain) reaching almost 10% following a 5% shock. We have to keep in mind that in Austria housing price rises ended, when the immigration inflow from the eastern European countries ended and when the extra housing supply came into the market. By 2001, property prices in Vienna were 14% lower compared with their 1994 levels. After 2005 the prices started to rise sharply again. On the other hand, in Spain the negative real rates, overbuilding and foreign purchases contributed to an unstable relation between GDP growth and housing prices. The shocks continue to impact real house prices for more than two years in all instances (except in the case of the Netherlands, in which they emerge as turbulent only after a year and remain so thereafter, in the post-Euro subperiod). Similar reactions in real house prices are evident following a shock in the country's stock market, which alternate between positive and negative and last well beyond two years. In none of the cases, however, there has been an overreaction of real house prices to such shocks.

Figure 3. Selected Generalized Responses of Real House Prices to Local Factors, pre- and post-Euro subperiods

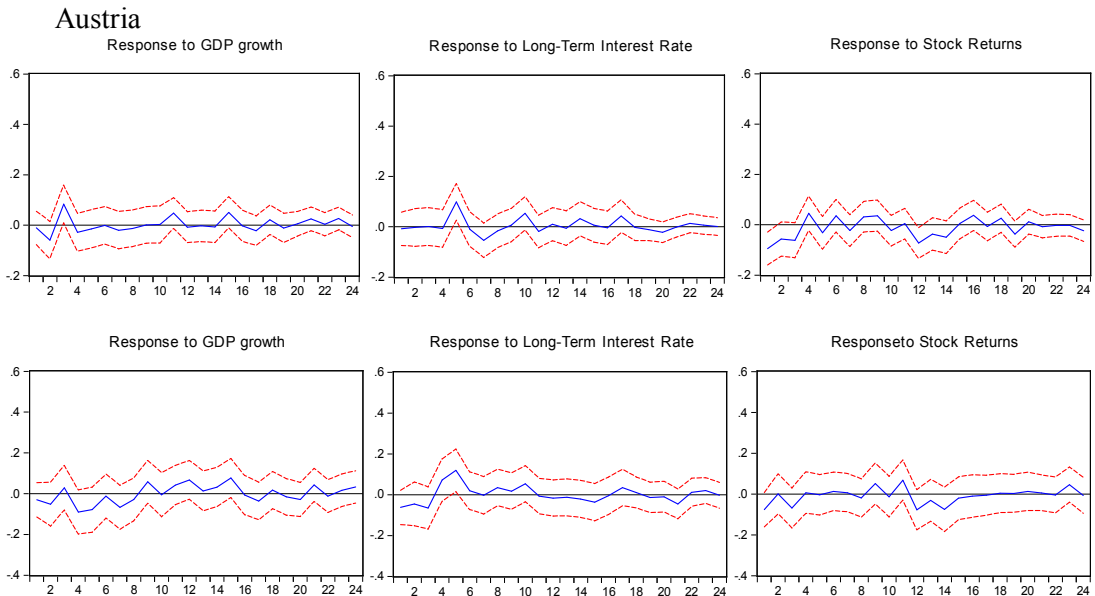


Figure 3. Selected Generalized Responses of Real House Prices to Local Factors, pre- and post-Euro subperiods (cont'd)

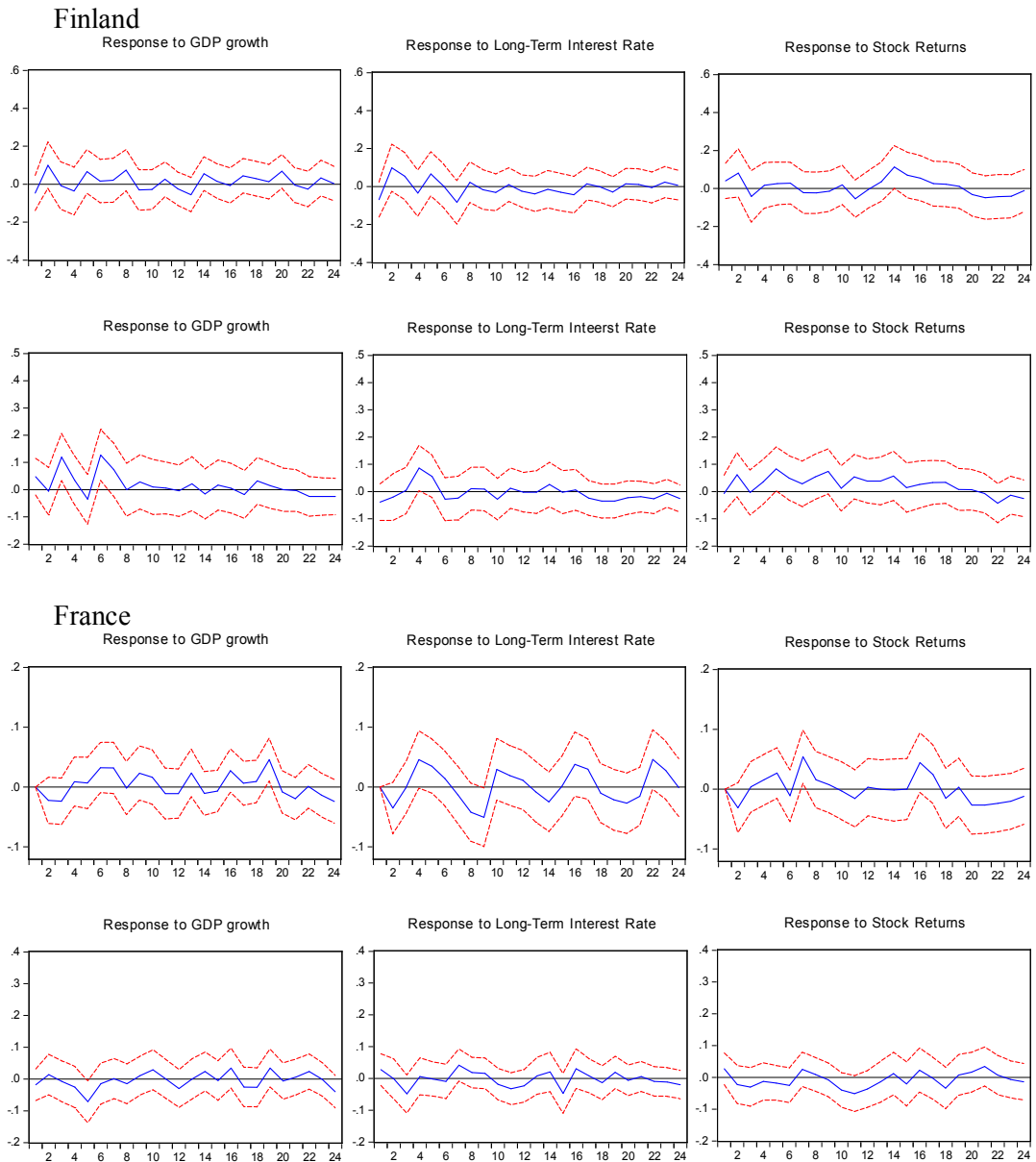
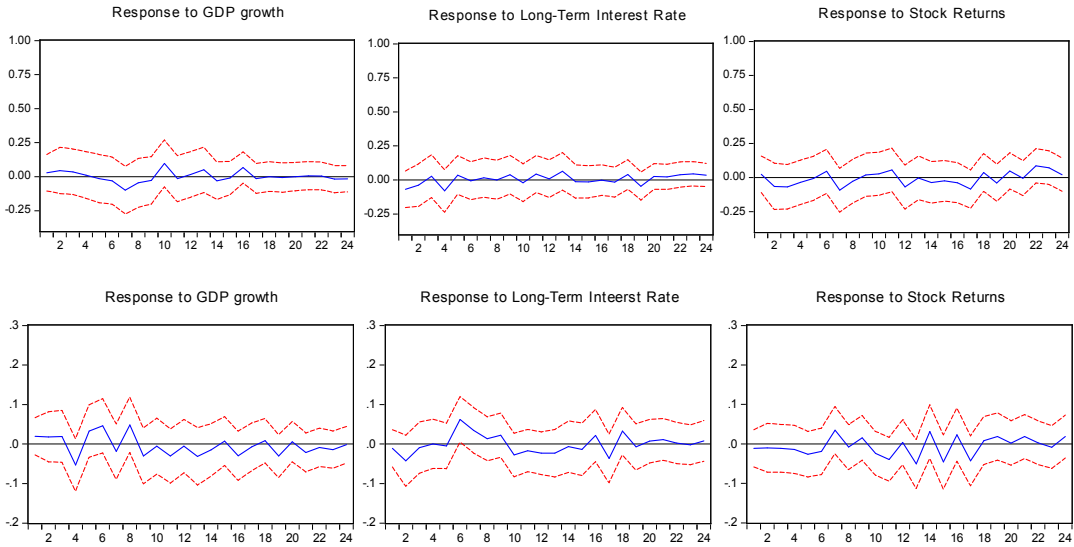


Figure 3. Selected Generalized Responses of Real House Prices to Local Factors, pre- and post-Euro subperiods (cont'd)

Germany



Italy

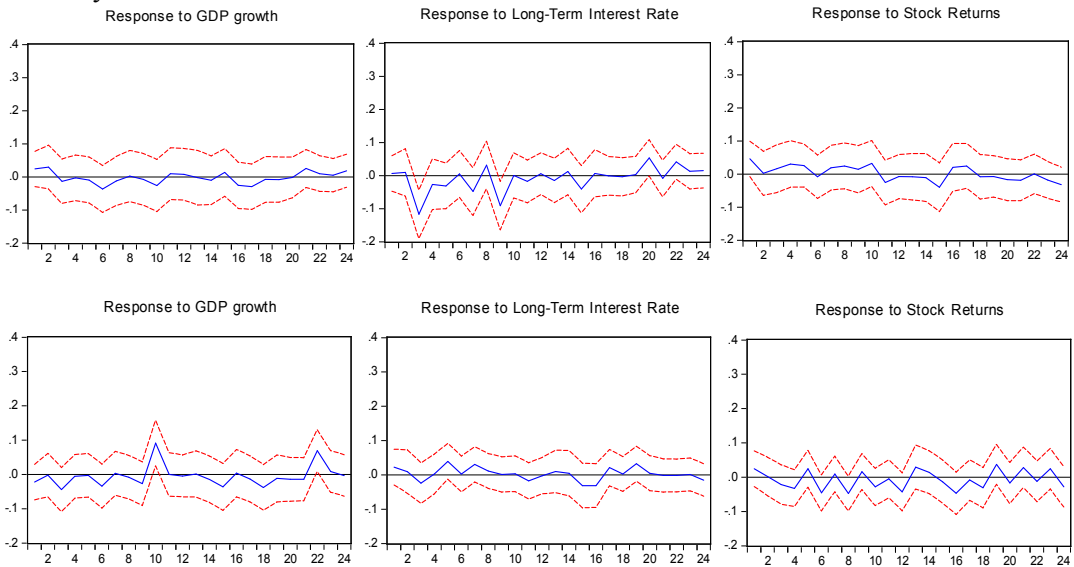
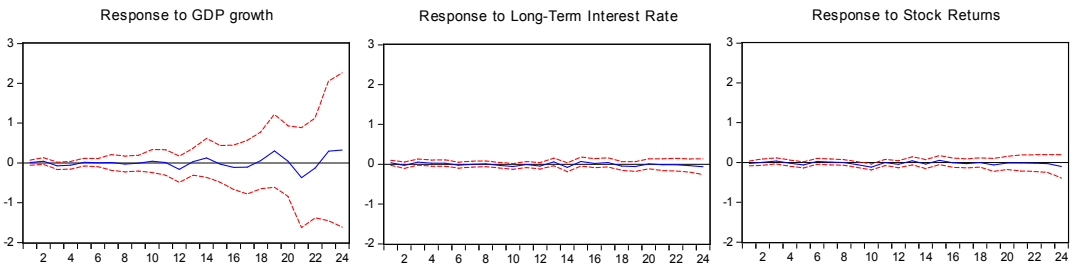
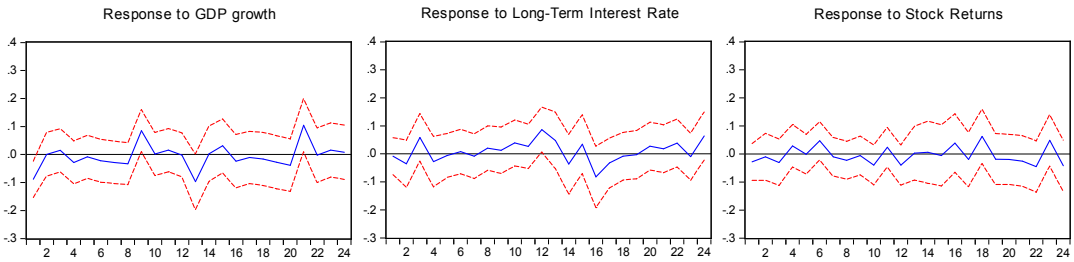
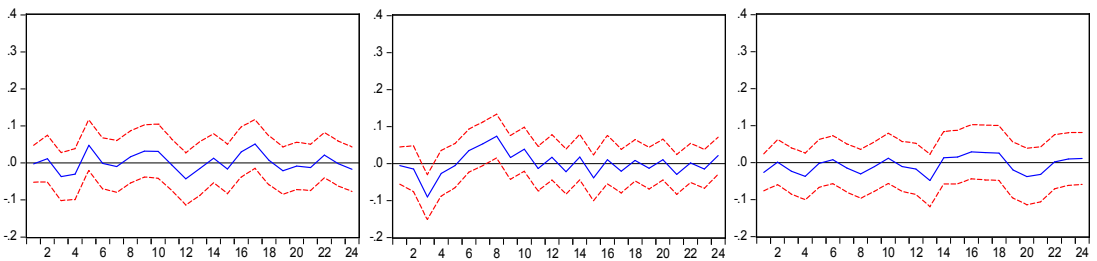
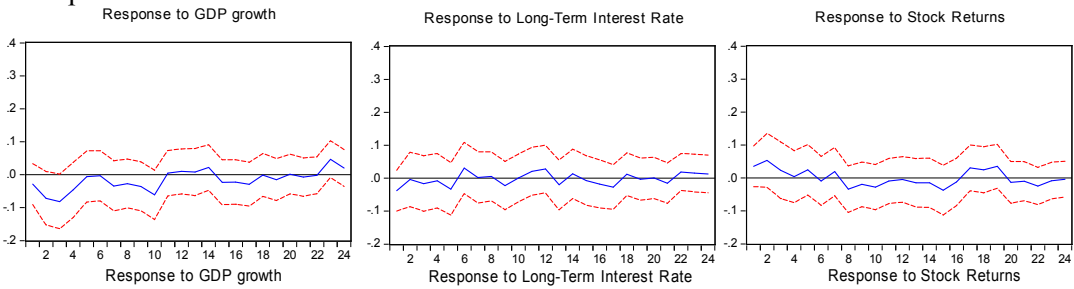


Figure 3. Selected Generalized Responses of Real House Prices to Local Factors, pre- and post-Euro subperiods (concl'd)

Netherlands



Spain

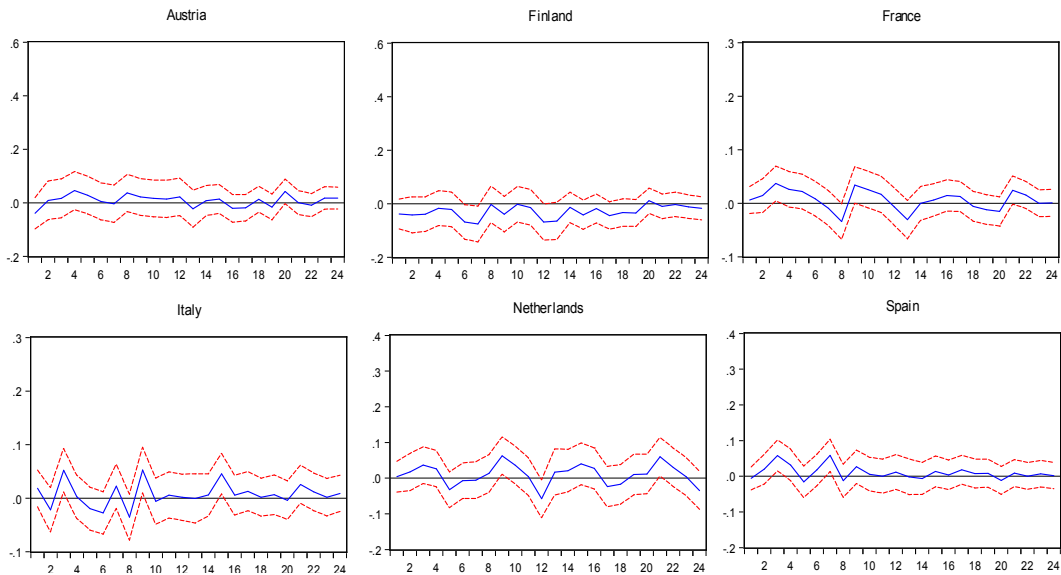


A more interesting case is the impact of a country's real long-term interest rate. In many instances, the dynamic reactions of a country's real house prices to shocks from the domestic long-term interest rate are strong and significant. It is worth noting, however, that these reactions differ across countries in intensity, direction and subperiod.

5.2 The impact of changes in German real house prices, interest rate and house price volatility

In this subsection, we explore the impact of changes in some of Germany's local magnitudes such as real house prices and long-term interest rates on the other countries' real house prices. We also consider the effect of house price volatility on the other countries' real house prices.

Figure 4. Response of Real House Prices to a Shock from Germany's Real House Prices



In Figure 4 we depict the pertinent generalized impulse responses to a shock from German real house prices. With the exceptions of Finland, which reacts negatively to a shock from German real house prices, and Spain, which reacts positively to such a shock, the rest of the countries' real house prices respond in an alternating pattern. In addition, such responses, albeit weak, either continue to remain turbulent, as in the cases of France, Italy and the Netherlands, and either die off within a year, as in the cases of Austria and Spain or extend well beyond two years, as in the cases of Italy and the Netherlands.

Figure 5 shows the impact of changes in Germany's real long-term interest rate on the other countries' real house prices. Once again, we detect different reactions of each country's housing market in both subperiods. For instance, in the

pre-Euro subperiod Austria's real house prices show an immediate and negative reaction (of about 15%) to a shock from the German long-term rate, whereas Finland's real house prices show an immediate but positive reaction (of approximately 10%) to such a shock. Thus, we observe overshooting in the real house prices of both countries. What explains Finland's real estate market behavior? Recall that Finland's housing market boomed during the 2000s (from 2001 to the end of 2008, as mentioned in section 3) and that this growth was due to strong economic growth and high sensitivity to global markets. The Netherlands' real house prices also react strongly and positively to shocks from Germany's long-term rate but not in an immediate manner (rather only after a year). Similarly, such behaviour by the Dutch real estate market was due to its strong domestic growth and low interest rates which aggressively encouraged home ownership. France's and Spain's real house prices seem to be the least responsive to such shocks.

Figure 5. House Price Responses to a Shock from Germany's Long-Term Interest Rate Panel A: Pre-Euro Subperiod

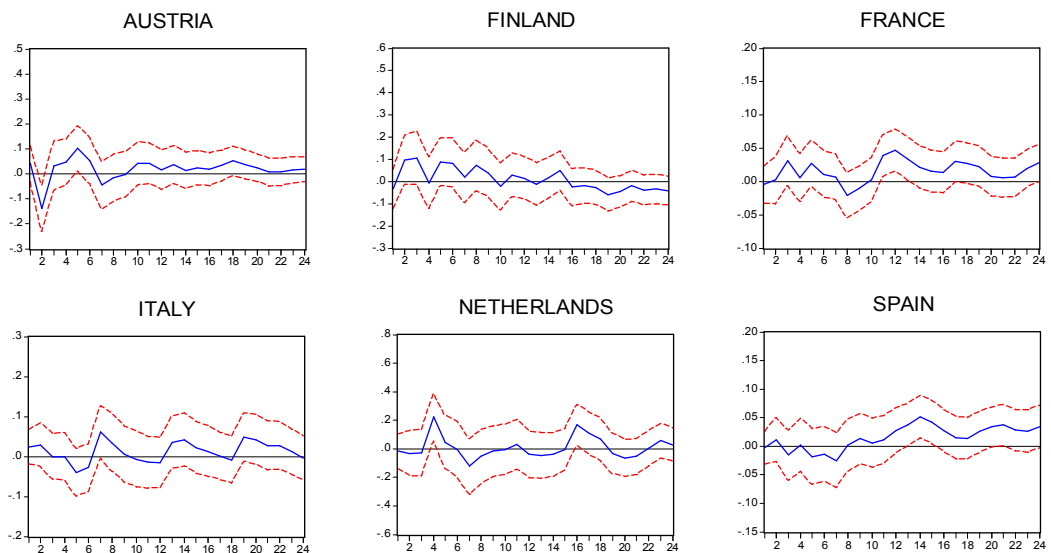
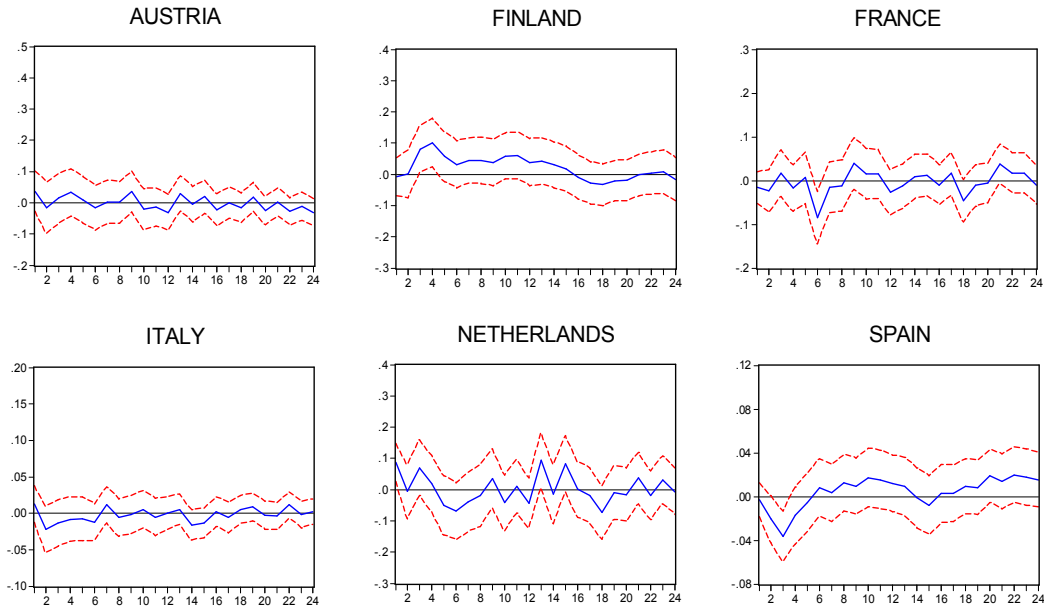


Figure 5. House Price Responses to a Shock from Germany's Long-Term Interest (concl'd)

Panel B: Post-Euro Subperiod



In the post-Euro subperiod, by contrast, we detect higher turbulence in the real house prices of France and the Netherlands, following a shock in the German real long-term interest rate, which alternates between positive and negative. Spain's real house prices continue to elicit minimal reactions to similar shocks. This finding suggests that the effect of EMU might have been minimal in achieving convergence in the euro area real estate market

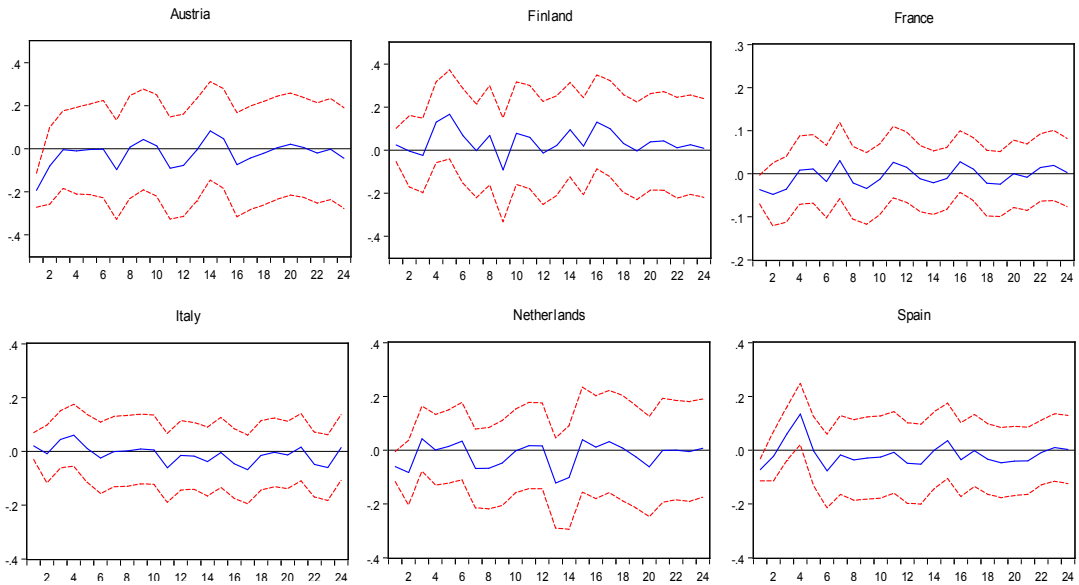
Taken together, the findings in Figures 4 and 5 imply that there is considerable heterogeneity in the way each country's house market reacts to shocks from their main trading partner, Germany, following a disturbance in its own house market and long-term interest rate. Such heterogeneity is evident even in the post-Euro sub period despite the efforts these euro countries have made to converge economically with Germany. In addition, we identify two groups of countries which react differently (positively or negatively) from others to shocks from Germany especially in the post-Euro sub period. One group includes countries which do not respond much to shocks from the German house market such as France and Spain, and another group which responds both positively and negative to the same shock.

Lastly, we examine the responses of each country's real house prices to a shock from Germany's real house price volatility. The volatility measure was derived from a GARCH(1,1) model using the country's macro variables namely,

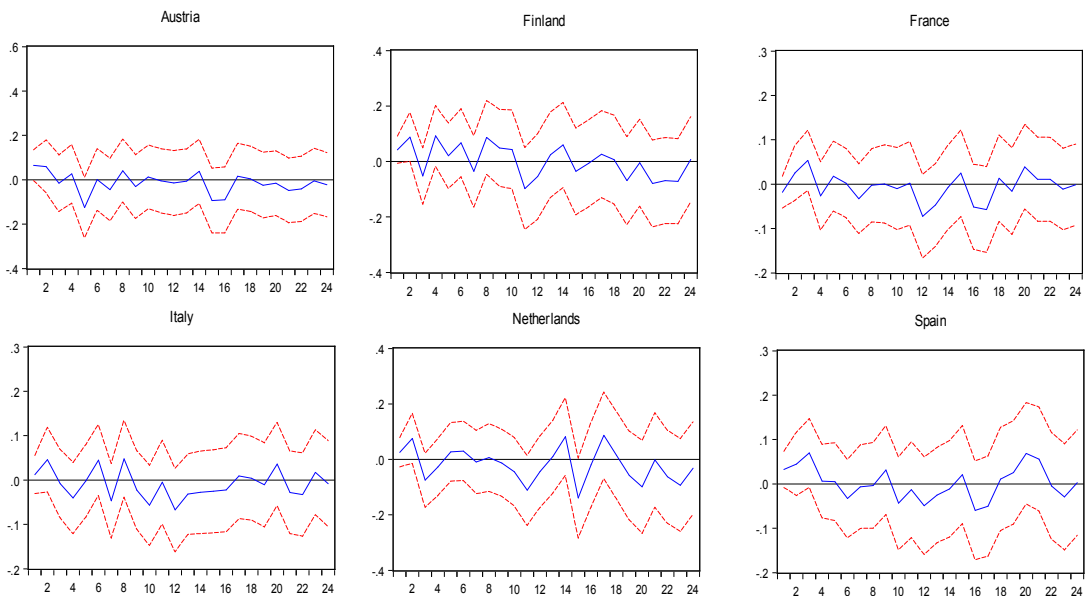
inflation, long-term interest rate and GDP growth. The generalized impulse responses are displayed in Figure 6 for both subperiods.

Figure 6. House Price Responses to a Shock from Germany's House Price Volatility

Panel A: Pre-Euro Subperiod



Panel B: Post-Euro Subperiod



From Panel A, we see that almost all countries' real house prices react in a turbulent manner. Notable are the reactions of Austria's house prices, which initially surface strong and negative to such a shock, and those of Spain's, which emerge initially strong and positive. In both instances, a 5% shock in the German real house prices elicits a 20% negative response by Austria's prices and a 20% positive response by Spain's house prices. The reactions taper off eventually after two years but still remain turbulent. The remaining countries' prices show similar volatility throughout the two year period shown in the graphs.

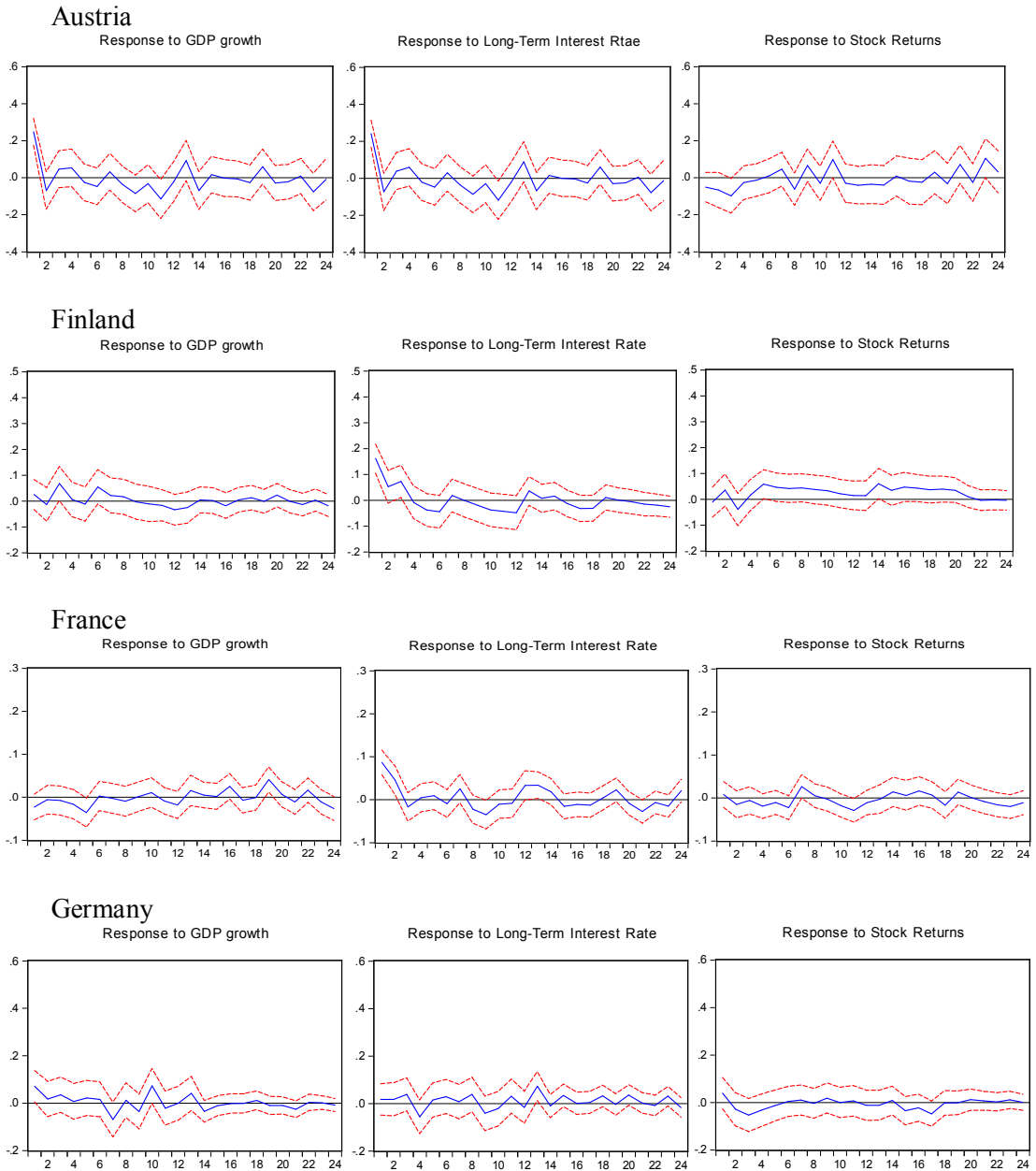
In the post-Euro subperiod (Panel B), we detect lower-intensity reactions to German volatility in the housing market by all countries' housing markets but still turbulent. Some interesting volatility patterns are evident in this case. For example, in the Netherlands and Spain volatility surfaces after a year while in Finland and Italy it surfaces within a year. Also, there are no early strong, positive or negative, reactions following a shock.

5.3 The impact of expansions and contractions on real house prices

Next we distinguish between expansions and contractions in real economic activity and observe from Figure 7 how real housing prices respond to local factors. A dummy variable takes the value of 1 in expansions and zero otherwise. All countries' but Germany's real house prices reveal a strong response to changes in their domestic real long-term interest rate during economic expansions. These responses emerge as positive and strong, initially, tapering off during the next year or so before they show a moderate reaction afterwards. In addition, many countries' real house prices respond strongly to economic expansions by showing robust economic growth (as evidenced by the responses to GDP growth) whether they manifest early enough, as in the cases of Austria, Germany and Spain, or after a few months, as in the cases of Germany and the Netherlands.

What explains these countries' real estate market behavior? For one thing, almost all of them enjoyed rapid economic growth in the 2000s due to their significant linkages in international trade and investment and due to government policies conducive to economic growth (like maintaining negative real interest rates). Moreover, in some countries the main driver of growth was construction (like in Spain) while in others strong economic growth (like in Finland). Germany's real estate market, being the largest and the most stable one within the Euro zone, explains why we observed 'well-behaving' reactions of the country's macro variables following economic expansions and contractions.

Figure 7. Generalized Responses of Real House Prices to Local Factors During Economic Expansions

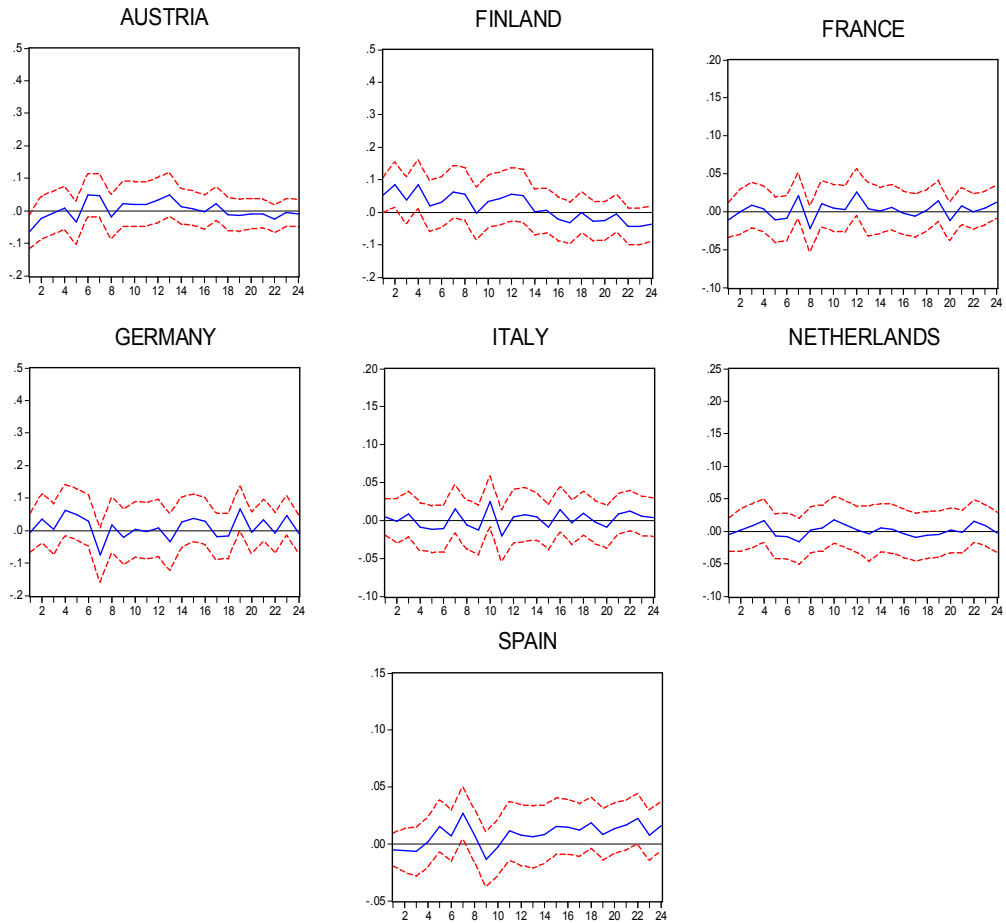


5.4. The impact of changes in US monetary policy

Finally, we explore the impact of foreign factors on each country's house prices. More specifically, we look at the potential impact of a change in the US's monetary policy on the housing market in the Euro zone. The main, and standard, instrument of monetary policy in the US is the federal funds rate. We also experiment with the US 10-year Treasury note (T-note) but found little qualitative difference in the results. We chose to report the results using the T-note. Figure 8 displays the generalized reactions of each country's house prices to a shock from the 10-yr T-note for the entire sample period, 1990 - 2010.

As we can see from the graphs, such a shock impacts most countries' real house prices minimally despite observing negative reactions by Austria's and Spain's prices and positive reactions by Finland's and Germany's prices. However, the fact that Germany's real house prices react in a stronger manner than those of the other countries is due, perhaps, to the fact that Germany is the leader in the Euro zone and it sets the group's monetary policy. Thus, it is expected that we see a stronger reaction to shocks from the US's long-term interest rate (the rate upon which mortgage rates are based). In general, in the remaining countries' cases the impacts are small and short-lived.

Figure 8. House Price Responses to a Shock from US 10-year Treasury Note, 1990:02–2010:04



6. Concluding Remarks

This study has set out to investigate if the apparent co movement of the housing prices in the seven major euro zone economies implies convergence of their housing markets.

Our findings suggest that the impact of local factors (especially the rate of interest), is strong and significant in many instances. However, the reactions differ across countries in intensity, direction and sub period.

Furthermore, all countries' but Germany's real house prices reveal a strong response to changes in their domestic real long-term interest rate during economic expansions.

Next we considered the impact of changes in German real house prices, interest rate and house price volatility. The findings suggest that there is considerable heterogeneity in the way each country's house market reacts to shocks from their main trading partner, Germany, following a disturbance in its own house market and long-term interest rate. Such heterogeneity is evident even in the post-Euro sub period despite the efforts these euro countries have made to converge economically with Germany.

Finally, the impact of changes in U.S. monetary policy (global factors), on all countries with the exception of Germany is small and short lived.

The heterogeneity, due to diversities in the local housing markets of the euro zone countries has implications in terms of making housing a more attractive asset to hold, from an investors' point of view. Housing as an asset class has advantages over other financial asset classes due to its lack of efficiency. Furthermore, the restructuring of pension schemes throughout the euro zone countries will lead individuals to view property acquisition as a safe haven in the context of provision for their retirement.

On the other hand, housing markets in the euro zone will continue to move in terms of prices and gradually converge with financial markets. This in effect implies future increases in volatility and reductions in price rigidities.

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