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Housing cycles in the major euro area countries

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Abstract: The recent burst of the house price bubble in the United States and its spillover effects on real economies worldwide has rekindled the interest in the role of housing in the business cycle. In this paper, we investigate the relationships between housing cycles among the four major euro area countries (Germany, France, Italy and Spain) over the sample 1980:Q1 – 2008:Q4. Our main findings are that GDP cycles show a high degree of comovement across these 4 countries, reflecting trade linkages, but much weaker ones for housing market cycles, where idiosyncratic factors play a major role. House prices are even less related than quantities across countries. We also find much stronger relationships in the common monetary policy period.

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1. Introduction

The recent burst of the house price bubble in the United States and its spillover effects on real economies worldwide has reinforced the interest in the role of housing in the business cycle. Cross country analysis need to determine the relative importance of common versus idiosyncratic factors in housing markets and its interaction with the rest of the economy. For instance, in the European Monetary Union (EMU) commonalities are to be expected, given the existence of a common monetary policy. Other determinants of housing markets may be more idiosyncratic. For example, the strength of housing wealth effects depends *inter alia* on differences in mortgage markets and the degree of home ownership. The transmission of policy interest rates depends on the relative importance of variable and fixed-term mortage interest rates. Availability of land and regulation can also influence considerably the extent and the time-lag between an increase in the demand for new homes and the time-lag of construction (Muellbauer and Murphy, 2008).

During the last years, most analyses have focused almost exclusively on house prices and their impact on consumption and GDP, and residential investment has always received substantial attention as part of the monetary transmission process. Recently, the importance of real residential investment for business cycles has been emphasized by Leamer (2007). This author claims that residential investment in the US is the best predictor of a coming recession. For France and Spain, Ferrara and Vigna (2009) and Álvarez and Cabrero (2009) also find that housing sector cycles are strongly correlated with future GDP cycles. In contrast, Bulligan (2009) finds that house prices and residential investment lag Italian GDP.

Existing idiosyncracies of housing markets suggests adopting a flexible enough methodological approach, capable of dealing with these differences. For this reason, we adopt nonparametric[1] approaches to define the cycle and date its turning points. The paper concentrates on the analysis of housing cycles, defined as deviations of series from their long-term trend, in the four largest Euro area countries (Germany, Spain, France and Italy). The nature of the paper is descriptive and its aim is to highlight a set of stylized facts, still missing in the Euro area empirical literature. The next logical step is to develop a theoretical model able to account for these stylised facts.

The analysis covers the period 1980:Q1-2008:Q4, thus including the last recession. We additionally investigate a shorter sample, covering the EMU period, since the adoption of a common monetary policy may have affected the relationship between housing and the business cycle. Our benchmark cycle is real GDP. We adopt a growth cycle approach instead of a business cycle approach for practical reasons; otherwise the number of cycles would be too small. In the analysis, we include the construction related GDP components such as households'

[1] Parametric approaches are more likely to suffer from specification problems and may not be flexible enough.

investment, investment in construction, non-residential construction investment and value added in construction. This set of variables is extended by considering additional construction real indicators, such as the number of building permits, the number of housing starts and employment in the construction sector. We also analyse real and nominal house prices.

We measure relationships between the different variables by analysing pairwise and multivariate comovement measures. Specifically, for each country pair, we compute cross-correlation coefficients and cross-concordance indexes. We also carry out a lead-lag analysis. The multivariate measures we use are effective dependence and average diffusion. Our results, presented in section 3, are consistent with previous empirical analysis supporting a broadly common GDP growth cycle among the four major euro area countries, despite the German cycle being characterized by stronger idiosyncratic features, including those related to the reunification process. In contrast, national housing markets seem to be weakly interconnected across countries. Indeed, both housing volume and price cycles are mainly driven by country specific factors. Housing volume cycles in Germany and Italy share a different cycle from France and Spain. Evidence from housing price cycles confirms the idiosyncratic nature of housing markets. We also find that synchronization has increased since 1999 among business cycles, and housing volume cycles, whereas housing prices cycles are more heterogeneous. Section 4 concludes.

2. Methodology

A large number of procedures have been developed in the literature to carry out decompositions of aggregate output into a trend – which accounts for long term growth- and a cyclical component –which measures short-term deviations from this trend (see e.g. Mills (2003)). Cyclical analyses of the housing sector have also employed a variety of procedures. For instance, Leamer (2007) has used linear kernels, Ferrara and Vigna (2009) the band pass Hodrick and Prescott's (1997) filter, Bulligan (2009) the Baxter and King's (1999) filter and Álvarez and Cabrero (2009a) the Butterworth's (1930) filter.

This variety of procedures employed to characterise housing cycles suggests the need to discuss their relative theoretical merits. Álvarez and Cabrero (2009b) provide a frequency domain interpretation of linear kernels for business cycle analysis and show that they present serious shortcomings. Gains of this filter –which measure to which extent each cyclical fluctuation contributes to the signal- vary with the precise kernel and bandwidth chosen, but the different variants share three qualitative regularities. First, the filters present an oscillatory gain (typically referred to as the Gibbs phenomenon). Second, short cycles (with periods less than 6 quarters) are almost fully passed through, instead of being suppressed. Third, cyclical fluctuations with long periods (more than 32 quarters) –which should be attributed to the trend- are only partially removed. In turn, the Hodrick and Prescott (1997) filter does not have an oscillatory gain, but being a high-pass filter damps cyclical fluctuations with high periods and leaves short-run cycles barely untouched. In contrast, the Baxter and King (1999) is a band-pass filter, so mainly focuses on the cyclical band. However, the fact that it is a finite moving average filter gives rise

to a Gibbs phenomenon. Moreover, the procedure involves losing *k* observations at the beginning and *k* at the end of the series -probably, the most interesting period to policy-makers. In standard applications, the filter involves the loss of the last 12 quarters.

In this paper, in order to minimize the shortcomings of the most common filters, we employ the Butterworth filter. This filter closely approximates the ideal band-pass filter (see Álvarez and Cabrero (2009b)). This method is well known in electrical engineering in its one sided form, but is hardly used for economic time series[2]. Butterworth filters can be low-pass or band-pass, one-sided or two sided and can be based on the sine function (BFS) or the tangent function (BFT). Interestingly, the Hodrick-Prescott filter is a particular low pass BFS, so that Butterworth filters are more flexible than the HP filter, suggesting that there may be benefits from their use. Here, we consider band pass filters, since our definition of the business cycle is the output of an ideal band-pass filter, *i.e.* a filter which passes through cyclical fluctuations of a time series belonging to a pre-specified band of frequencies (pass band), while removing components at higher and lower frequencies. In formal terms, the ideal band-pass filter (G_I^{BP}) has a gain function given by

$$G_I^{BP}(p) = \begin{cases} 0 & if\ |p| < p_1 \\ 1 & if\ p_1 \le |p| \le p_2 \\ 0 & if\ |p| > p_2 \end{cases}$$

which means that cyclical fluctuations with lengths (*p*) belonging to the interval $[\,p_1, p_2\,]$ pass through the filter untouched, but all other fluctuations are completely removed. Use of a two-sided version of the filter allows to avoid phase shifts -present in one sided versions- that would distort the timing of turning points. We consider a Butterworth filter of the tangent, since it fully suppresses high frequency fluctuations, in contrast with Butterworth filters of the sine.

Butterworth band-pass filters of the tangent[3] can be expressed in the time domain as symmetric, two sided filters in the lag (L) and forward (F) operators given by

$$BPF(L,F) = \frac{(1-L^2)^d (1-F^2)^d}{(1-L^2)^d (1-F^2)^d + \lambda(1-\alpha L + L^2)^d (1-\alpha F + F^2)^d}$$

where *d* is an integer parameter, $\alpha = \cos\left(\left(\omega_{p2} + \omega_{p1}\right)/2\right)/\cos\left(\left(\omega_{p2} - \omega_{p1}\right)/2\right)$, ω_{p1} and ω_{p2} are the lower and upper limits of the band-pass, respectively and λ is a parameter to ensure that the

[2] But see Stock and Watson (1990) or Gómez (2001).

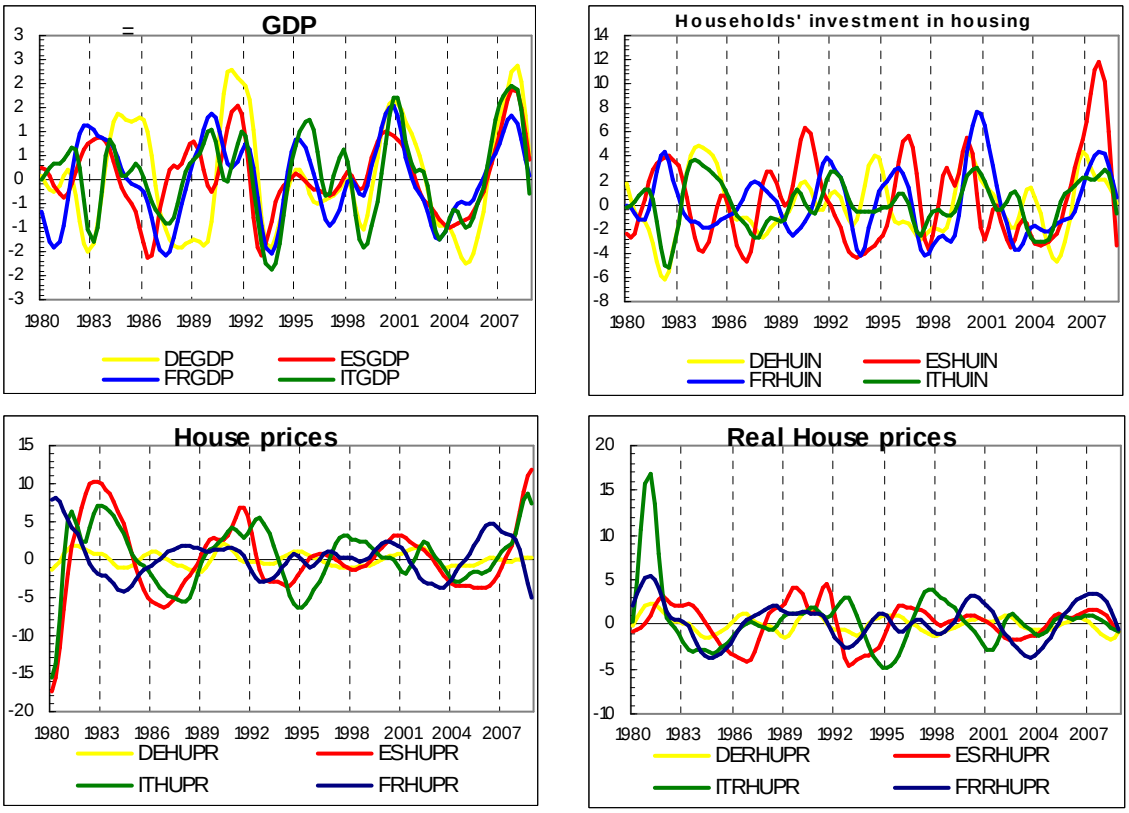
[3] Alternatively, they can be given a model-based interpretation: the band-pass BFT can be obtained as the best linear estimator, in the mean squared sense, of the signal in a signal-plus-noise model, where the signal follows a particular ARIMA model.

gain of the filter at a pre-specified period equals one-half. Note that larger values of *d* produce sharper filters, so there is better approximation to the ideal filter[4].

Following Gómez (2001), we first extend series with ARIMA forecasts and backcasts to minimise the size of revisions and then estimate the model-based trend-cycle component using the methodology in Gómez and Maravall (2001). Finally, we apply the band-pass BFT to the trend cycle component. Our use of trends instead of seasonally-adjusted series or raw data leads to less noisy cycles, thus making easier the detection of turning points.

Estimated cycles for the four main variables in our analysis are presented in Figure 1.

Figure 1: Estimated cycles for GDP, residential investment and nominal and real house prices (BFT filter)



3. Results

In this section, we describe the cyclical comovements across the 4 major euro area economies. The main focus of the analysis is the housing market and we distinguish between housing related real and nominal variables (see appendix 1 for a description of the database). Among housing market indicators, our preferred variables are residential investment and house prices in

nominal and real terms. We additionally consider some quantitity related construction indicators[5]: investment in construction, non residential construction investment, value added, employment in the construction sector, building permits and housing starts.

We refer to synchronization as the degree to which two or more variables co-move contemporaneously. We measure it for every country pair by the contemporaneous correlation coefficient and by the concordance index between their respective cycles. Since leading/lagging relationships may exist between variables –which are not captured by contemporaneous measures-, we also consider their dynamic relationships, by analysing, the maximum cross-correlation coefficient, as well as the cross-concordance index over a range of leads (+) and lags (-), between +4 and -4 quarters. Finally, it is worth bearing in mind that those two measures of synchronization complement each other nicely. Indeed, on the one hand, the correlation coefficient measures the degree to which two variables are linearly related, by using the whole information in variables, while, on the other hand, concordance measures focus only on turning points, so they can deal with linear and non-linear relationships between variables, at the expense of discarding some information.

In addition, we consider a measure of multivariate linear dependence put forward by Peña and Rodriguez (2003). This measure can be thought of as a generalisation of the standard squared correlation coefficient in the bivariate case. Specifically, this measure is defined as

$$PR = 1 - |R|^{1/p}$$

where $|R|$ denotes the determinant of the correlation matrix of the variables of interest and p denotes the number of variables. This measure is bounded between 0 and 1 and a higher value means a higher degree of linear dependence. A set of orthogonal variables leads to $PR=0$ and $PR=1$ entails perfect collinearity among variables. An additional property of this measure is that it can be used to compare groups with a different number of variables.

The results of our analysis refer to the sample 1980q1-2008q4. We also consider a sample for the common monetary policy period. The choice tries to strike a balance between the need to incorporate enough cycles in order to get meaningful results and the need to assess any likely change in the most recent subsample.

3.1 Correlation analysis

First, we consider aggregate GDP cycles, then housing volumes construction cycles, and, finally housing price cycles. Results are summarized in Table 1.

[5] Since the housing sector only represents between 40% and 60% of construction value added, some variables also reflect developments in other activity branches, such as commercial building and infrastructures.

a) Aggregate activity cycles

First, we focus on correlation analysis. Table 1 reports results for GDP and other macro-variables. GDP is taken as a benchmark against which to evaluate results for housing related variables. An extended empirical literature is available pointing out that GDP cycles in the Euro area are strongly synchronized (see, *e.g.* de Bandt, Herrmann and Parigi (2006)), and that synchronization has increased since the mid-nineties (see the review in Haan, Inklaar and Jong-A-Pin (2008)). Our results, using a different methodology, confirm such findings: the average contemporaneous correlation coefficient between all cross country GDP pairs is 0.58, with pairwise contemporaneous correlations ranging between 0.47 (between Germany and Spain as well as Germany and France) and 0.66 (between Italy and France as well as France and Spain). In terms of effective dependence, we find a value of 0.36, which is the highest among the variables considered in table 1. The cross-correlation analysis reveals that in the majority of cases the bulk of comovements is contemporaneous, with the exception of Spain, which tends to lead the other countries (Germany and Italy by 2 quarters and France by 1 quarter). Furthermore, pairwise correlation coefficients show that activity in France, Spain and Italy has important common elements, whereas the German cycle is characterized by stronger idiosyncratic features, reflecting the reunification process and its impact on German housing policies, a fact probably related to the reunification process (appendices 4 and 5).

b) Construction cycles

Synchronization between *residential investment* cycles is considerably lower than that observed between GDPs, the effective dependence being 0.21. This suggests that in domestic housing markets country-specific factors tend to play a stronger role. Indeed, with the exceptions of Italian and German cycles, which are strongly correlated (0.71), and, to a lesser extent, the French and Spanish cycles (0.45), the remaining pairwise coefficients are generally low. Cross-correlation analysis confirms this point and shows that the Spanish housing investment cycle slightly leads the French one.

Residential investment refers to completely new buildings and also to already existing buildings. Since it is unclear whether the two types of investment are complements or substitutes, it is worthwhile to separate these two components. National Accounts data does not allow this distinction, but the number of housing starts and building permits may proxy for investment in new buildings. Unfortunately, data on housing starts are only available for Spain and France. The time series for the number of building permits is too short for Italy and in Germany several government interventions in recent years aimed at the abolishment of subsidies for family houses provoked each time a strong anticipation of permits. This, in turn, severly distorts the correlation and lead-lag relationships to other housing variables. Nonetheless, for France and Spain we get the interesting result that the correlation between *housing starts* cycles is much stronger (0.73) than when considering total residential investment, with the French cycle now

slightly leading, instead of lagging, the Spanish one. Also *building permits* cycles are also strongly synchronized between France and Spain. German building permits does not appear to be related to the others.

Regarding cycles in *non-residential construction investment* we find intermediate values of correlation of the French cycle with respect to the other ones (0.45 with Germany, 0.32 with Spain, 0.26 with Italy). Cross-correlations reveal that the Spanish cycle leads the Italian and French ones, while the German cycle, besides a mild lead with respect to the French cycle, seems unrelated to the Italian and Spanish ones.

Table 1

Average contemporaneous correlations and effective comovements (*)				
	Correlations		Effective comovements	
	1980:Q1 2008:Q4	1999:Q1 2008:Q4	1980:Q1 2008:Q4	1999:Q1 2008:Q4
GDP	0.58	0.88	0.36	0.77
Investment in construction	0.15	0.23	0.14	0.21
Households' investment in housing	0.29	0.62	0.21	0.40
Non residential construction investment	0.12	0.45	0.17	0.34
Construction Value added	0.19	0.51	0.15	0.36
Employment in construction sector	0.27	0.59	0.23	0.48
Building permits	0.26	0.38	0.24	0.36
Housing starts	0.70	0.80	0.29	0.40
House prices	0.09	0.17	0.28	0.35
Real House prices	0.33	0.22	0.18	0.34

(*) Effective comovement measure correspond to Peña and Rodriguez (2003) efective dependence measure
Colour key: coefficient between 0.35 and 0.65; coefficient higher than 0.65

Synchronization among *total investment in construction* variables is lower than that observed for residential investment (pairwise average 0.15 and effective dependence 0.14), probably reflecting that public construction is not related across countries. In particular, values close to zero are found with respect to Germany and Italy[6], while a positive and high value is found between Spain and France (0.60). Cross-correlation analysis reveals the leading nature of the Spanish cycle with respect to the French and Italian cycles and the lagging nature of the latter. German cycles seem to be uncorrelated at any lead and lag with the remaining countries, showing, thus, highly idiosyncratic dynamics.

We also find a weak synchronization of employment in the construction sector (pairwise average 0.27, effective dependence 0.23), with the only exception of a strong synchronization between the Spanish employment cycle and the French one (correlation 0.73). Lead-lag analysis confirms these results. Employment is nonetheless stronger synchronized than investment. Synchronization among *value added in construction* variables is low on average (0.19), ranging

[6] This indicates a negative correlation between German residential and Italian non-residential construction investment and also between German non-residential and Italian residential investment, offsetting the strong correlation between German and Italian residential investment.

from negative between Italy and Germany (-0.25) to mildly positive between Italy and France and France and Spain (around 0.4 in both cases). Lead-lag analysis suggests that Spain tends to lead the other countries.

c) House price cycles

The idiosyncratic nature of national housing markets is even clearer for house price cycles. These are even more country-specific (average pairwise correlation 0.10) than volume housing cycles. We find a strong relationship between cycles in Spain and Italy (correlation 0.79) and a negative correlation of the French cycle with the Spanish and Italian ones (-0.41 for both countries). Furthermore, the German cycle is weakly correlated with those of the other countries. Results from cross-correlation analysis suggest that the negative contemporaneous correlation of the French cycle with Italy and Spain reflects the mildly leading nature (cross-correlation of 0.40 and 0.47 respectively) of the former with respect to the latter (by around four quarters).

As the behaviour of nominal house prices might reflect that of the general price level (see, *e.g.* Tsatsaronis and Zhu (2004) arguing that housing plays the role of a hedge against inflation), we have also performed the same analysis for the real house price indexes. It turns out that the high value of comovements observed between nominal indexes of Italy and Spain is mainly driven by the common behaviour of inflation in these two countries, so that the real house price comovement is considerably lower (correlation 0.15). Indeed, we find positive and intermediate correlation values (0.51 from 0.06) between France and Germany, followed by positive values between Italy and France (0.45 from -0.41) and Spain and France (0.43 from -0.41). A lead-lag analysis indicates that most of the comovements are contemporaneous, although Spain lags with respect to the remaining countries.

3.2 Concordance analysis

After discussing the results based on correlation coefficients, we focus on measures of concordance based on turning points in cycles estimated previously (Figure 1 and Appendix 3). That is, we look for dependence and leads and lags between countries by only taking the dates of turning points into account. It is noteworthy that, by construction, concordance indexes and correlation coefficients are not directly comparable. Especially, a correlation coefficient lies between -1 and 1, while a concordance index belongs to the [0,1] interval. Furthermore, as mentioned above, the two synchronization measures focus on different and complementary aspects of the cycle, so that in the following some results might differ from those commented upon in the correlation analysis.

The first step in the concordance analysis is to identify peaks and troughs in the Butterworth band –pass filter cycles estimated above. Several approaches have been put forward in the literature to identify turning points in macroeconomic time series, either based on parametric modelling or on non-parametric methods. Most parametric procedures are based on the Markov-

Switching approach. Following the seminal work by Hamilton (1989), several authors have tried to identify turning in business cycles, including Krolzig (2001), Ferrara (2003), Artis *et al.* (2004) or Bengoechea *et al.* (2006). In contrast, non-parametric methods generally rely on pattern recognition algorithms, as in the standard Bry-Boschan (1971) algorithm. In this paper, we implement the quarterly extension of the Bry-Boschan algorithm proposed by Harding and Pagan (2002) to locate peaks and troughs of the series. We argue that in order to date turning points in the past it is preferable to use a simple tool that avoids specification issues. Basically, the heart of the Bry and Boschan (1971) algorithm, for a time series (y_t), is given by

Peak at t: $\{ y_t > y_{t-k} , y_t > y_{t+k} , k=1,\ldots, K \}$
Trough at t: $\{ y_t < y_{t-k} , y_t < y_{t+k} , k=1,\ldots, K \}$,

where K=2 for quarterly time series. This approach is based on a variation in growth rates over a bandwidth in comparison with an a priori threshold set to zero. The choice of the threshold value is somewhat natural in this case, but results are not sensitive to slight and meaningful variation of such a threshold[7].

Once turning points have been identified, for each variable of each country I, we compute a binary variable (S_{it}), the so called reference cycle, such that S_{it} is equal to 1 during a descending phase of the cycle (that is between a peak and a trough), and zero otherwise. Our aim is to evaluate whether, for each variable, there is a common pattern and synchronisation among the countries. There are several ways to assess synchronisation. The simplest one is to compute a concordance index which measures the fraction of time that the reference cycles of different series are in the same phase (see, for example, Harding and Pagan (2002) or Artis *et al. (*2004)) and which is bounded between 0 and 1. For two countries i and j, the concordance index is defined as:

$$CI = \frac{1}{T}\left\{\sum_{t=1}^{T} S_{it}S_{jt} + \sum_{t=1}^{T}(1-S_{it})(1-S_{jt})\right\}$$

At each date t, this concordance index is equal to 1 when $S_i = S_j$ and to 0 when $S_i = 1\text{-}S_j$. In order to take possible leads and lags into account, we also compute a cross-concordance index (CCI), based on the concordance between $S_{i,t}$ and $S_{j,t-h}$, for various positive and negative h. For each pair of countries, we retain the maximum CCI over all various leads and lags. As in the case of the maximum cross-correlation, this lead-lag is taken as an estimate of the relative timing between turning points in the cycles of countries i and j.

As in the above correlation analysis, we compute the contemporaneous and the cross-concordance indexes for h such that $h \in \{-4,-2,-1,+1,+2,+4\}$, and we retain the lag that maximizes the CCI. In addition, when the concordance is found to be strong between two

[7] Results available upon request.

countries, we carry out a lead-lag analysis that consists in computing the average lead (lag) of turning points in a country by comparison with another one. This lead-lag analysis is complementary to that with cross-concordance indexes. Results are presented in Appendices 8 and 9.

a) Aggregate activity cycles

Since 1980, all 4 countries have experienced four complete cycles from peak to peak, if we include the last peak that we provisionally place in 2007 Q4 or 2008 Q1 depending on the country[8]. The analysis based on concordance indexes confirms that GDP comovements among the four countries are strongly synchronised: this index ranges from 0.61 (between Italy and Spain) to 0.73 (between Italy and France). The relationships between France and Germany (CI of 0.71), France and Spain (CI of 0.72) and Germany and Italy (CI of 0.72) are also clearly significant. Regarding lead-lag relationships, we note that the German cycle appears to be lagging with respect to other cycles (one quarter with respect to France and four quarters with respect to Spain). Such a feature may be the result of the export-oriented nature of the German economy, which depends, to a larger extent, on demand from other Euro area countries. We have carried out a lead-lag analysis on turning points (see figure 2) and computed average and median distances between turning points (in quarters). Because of the small number of points, median values are useful to avoid a too strong influence of extreme values in the sample. It turns out that the German cycle clearly lags Spanish and French ones by around 3 quarters, while it is more coincident with the Italian one. As in the case of correlation, we find evidence that the Spanish and French GDP growth cycles tend to lead the remaining cycles.

b) Construction cycles

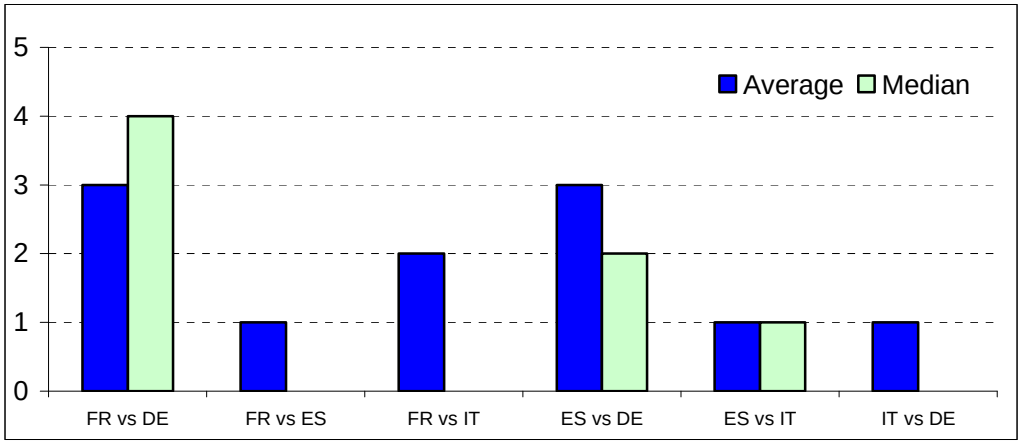
Regarding *residential investment* cycles, concordance indexes values confirm the results from correlation analysis that synchronization is lower than for GDP cycles. Also in line with previous analysis is the high country concordance found between France and Spain (0.72) and between Italy and Germany (0.69). The latter is generally poorly synchronized with other countries, confirming the specific behaviour of German households, as well as the effect of the German reunification. Note also that, according to the concordance measure, the Italian residential investment cycle lags the remaining ones, in contrast with the correlation analysis (see figure 3). Regarding *building permits* and *housing starts* concordance indexes between France and Spain are strong, (equal to 0.75) with a lead of two quarters in favour of France. The lead-lag analysis reveals an average lead of one quarter and a median lead of 2 quarters for the French building permits, while the average and median leads are both estimated at 2 quarters for French housing starts. In line with results from the correlation analysis, the evolution of the

[8] Note that, due to end-point effects in filtering, the dates of this last peak are still provisional and can be changed in the future when including new data. However, we have decided to include them in our analysis.

number of building permits in Germany does not appear to be related to the one in France and Spain.

Figure 2

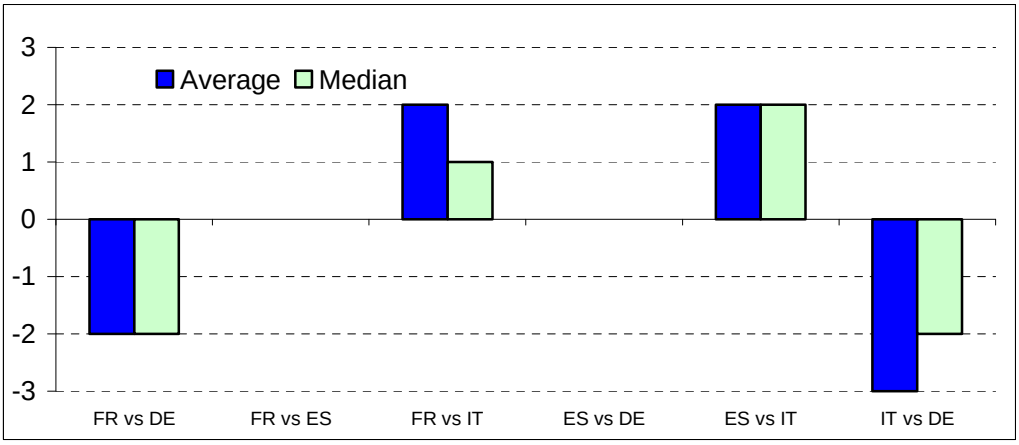
Lead-lag analysis for GDP growth cycles. Country pairs (*)
(Average and median duration in number of quarters)



(*) First country leads second country

Figure 3

Lead-lag analysis for residential investment cycles. Country pairs (*)
(Average and median duration in number of quarters)



(*) Positive(negative) value if first country leads(lags) second country

Regarding *non-residential investment in construction*, a high degree of concordance appears between France and the other three countries. France lags Germany (1 quarter, CCI=0.70) and Spain (4 quarters, CCI=0.68), while it leads Italy (1 quarter, CCI=0.72). Note also that Spain tends to lead other countries. As for the correlation analysis, the significant comovement of non-residential investment may be explained by the stronger interconnection of business activities as opposed to the more local nature of housing markets.

Analysis of the *investment in construction* cycles confirms the highly idiosyncratic nature of German volume cycles. Otherwise, relationships between the remaining series for investment in construction are characterized by stronger ties (between France and Spain CI of 0.79). Furthermore we note that Italy lags France (2 quarters) and Spain (4 quarters), with a high degree of concordance (0.74 and 0.71, respectively), a finding in line with results from the correlation analysis.

E*mployment in construction* is weakly related across countries in terms of cyclical concordance, with the exception of the strong link between France and Spain (CCI=0.75), in line with evidence from correlation analysis. This result suggests the relevance of country specific differences in labour market' contracts. *Value added in construction* cycles are related across countries: concordance analysis suggest, in line with correlation analysis, that Spain leads the remaining countries (France, CCI=0.71, Germany CCI=0.70, Italy CCI=0.80) by around two quarters. However, concordance analysis shows a tighter relation between the countries than correlation analysis.

c) House prices cycles

Lastly, we focus on price dynamics by considering cross-country relationships both in nominal and real terms. Overall, both variables reinforce the diagnosis of idiosyncratic behaviour for domestic housing markets, especially when considering nominal house prices. Indeed, we observe that high concordance indexes are very rare among nominal prices. We observe a high concordance value between Spain and Italy (0.78), Spain leading by four quarters. We find a strong relationship between Germany and Spain (CI equal to 0.69), Germany being leading. The rest of CIs are not higher than 0.60. We also note that the Italian cycle seems to be systematically lagging.

Synchronisation is slightly higher in terms of real house prices. For example, France and Germany present the highest concordance index value (CCI=0.68), France being slightly leading by one quarter. We also note a reasonable degree of concordance between France and Spain (CCI=0.65), France leading by one quarter. Otherwise, the degrees of concordance are very weak. We observe again that the Italian cycle seems to be systematically lagging.

To sum up the results based on the correlation and concordance measures of synchronization, we confirm the notion of a broadly common GDP growth cycle among the four countries, despite the German cycle being characterized by stronger idiosyncratic features. Such high level of comovement is not found among national housing markets. Indeed, both housing volume- and price- cycles are mainly driven by country specific factors. As far as volume cycles are concerned, Germany and, to a lesser extent, Italy share a different cycle from that between France and Spain. Moreover, Spain tends to lead the former countries. Evidence from housing price cycles confirms the idiosyncratic nature of housing markets.

3.3 Convergence or divergence in the monetary union?

In this section, we analyse the change in synchronization in the more recent 1999-2008 subsample, referred to as the EMU sample hereafter. We compare average pairwise contemporaneous cross correlations and the effective dependence measure over 1980-2008 with that over the EMU sample. As a multivariate measure of concordance, we consider the average classical diffusion index[9], defined at each date by

$$DI_t = \frac{1}{n}\sum_{i=1}^{n} S_{i,t}^{j}$$

where $S^{j}_{i,t}$ is the binary variable for variable j in country i. We put forward a multivariate synchronisation index (*SI)*, that measures the fraction of time the n countries are simultaneously in the same phase of the cycle (i.e.: for i=1,…,n, $S_{i,t}$ = 0 or $S_{i,t}$ =1). This index is bounded between 0 and 1. Thus, we define *SI* by

$$SI = \frac{1}{T}\sum_{t=1}^{T} 1\{(DI_t = 1) \bigcup (DI_t = 0)\},$$

where 1{.} is the indicator function. Table 1 and figures 4, 5, and 6 clearly show that synchronization for the different variables has increased, regardless of the way it is measured. Particularly striking is the increase in synchronization measures for GDP comovements, a finding highlighted in much of the existing empirical literature (*e.g.* Cabrero *et al.* (2004)). More interesting, however are the results concerning housing market variables. Here it is worth distinguishing between volume and price variables. Volume cycles clearly show an increase in synchronization common to all three measures considered, particularly strong for residential investment and milder for housing starts, which already showed a very high value[10]. Results for house prices are mixed, both nominal and real prices have increased according to two measures and decreased according to one measures. Furthermore, variations are never as strong as for volume variables.

[9] Several measures are available in the literature. For example, Harding and Pagan (2006) have proposed a test for multivariate non-synchronisation and perfect synchronisation. Candelon et al. (2009) have extended this test in order to take a small number of cycles into account.

[10] This high value only reflects developments in France and Spain, as there is no data on housing starts for Germany with its rather idiosyncratic housing market, while for Italy the available time period is to short.

Figure 4

Bivariate synchronization: average pairwise correlation

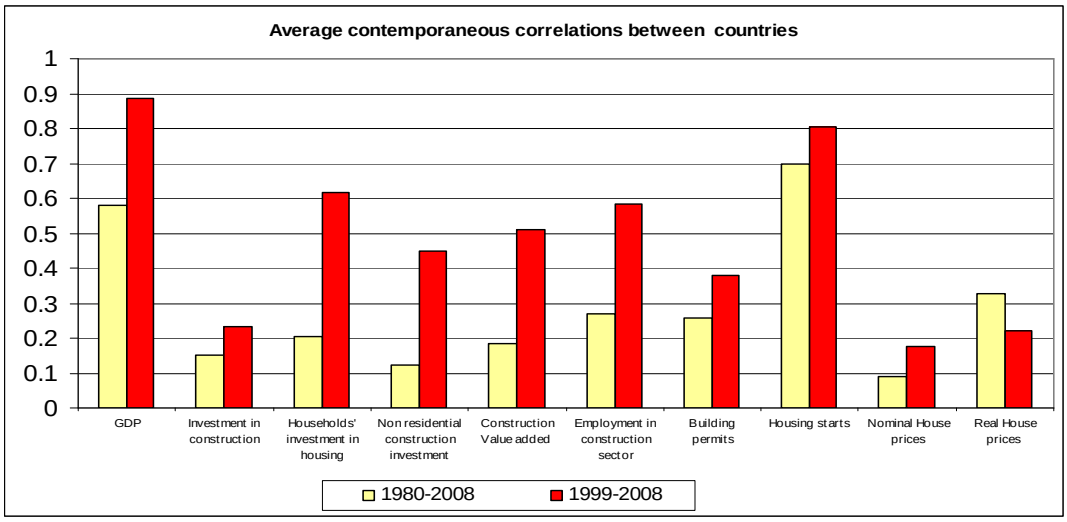


Figure 5

Multivariate synchronization: effective dependence

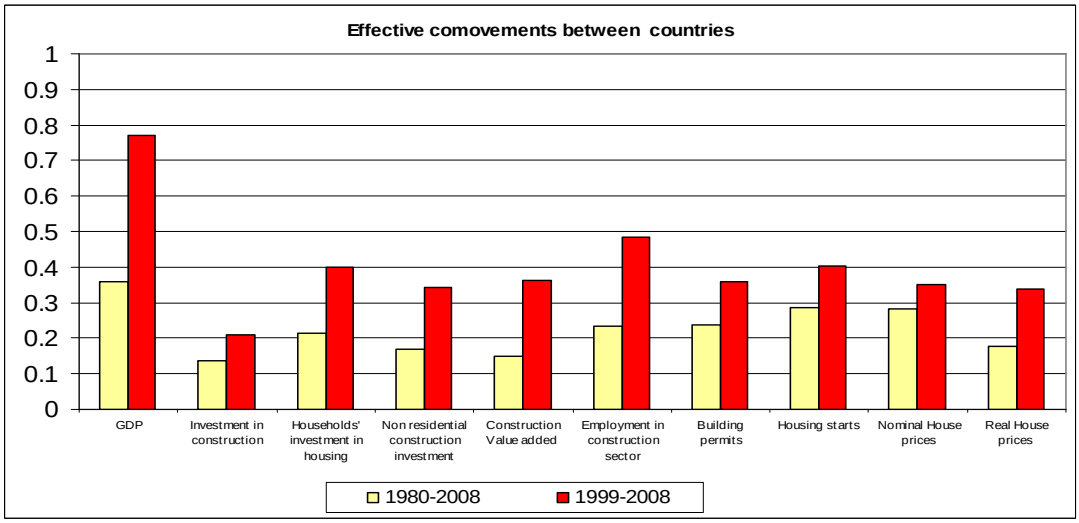
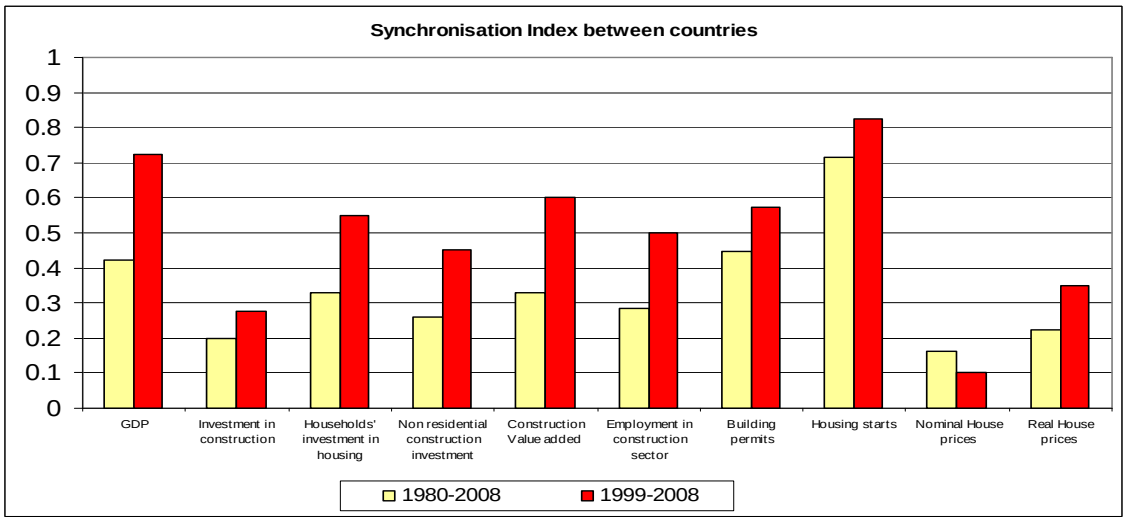


Figure 6

Multivariate synchronisation: diffusion index



4. Conclusions

Recent years have seen an explosion of papers focussing on housing price cycles and, to a much lesser extent, housing volume cycles. In this paper, we contribute to this latter incipient literature by analysing housing cycles in the four major euro area countries[11]. We take a fully nonparametric approach both in the calculation of cyclical components and in the dating of turning points.

We find that, in the four major euro area countries, GDP cycles show a high degree of comovement, most likely due to trade linkages, although idiosyncratic factors play a larger role in Germany than in the other countries. Cross country comovements are mostly contemporaneous, but developments in Spain tend to lead those in Germany, Italy and France by 1 or 2 quarters. In contrast, comovements are substantially weaker for housing market cycles, where country-specific or local variables, such as land availability or regulation, play a major role. Again, residential investment developments in Spain precede those in the other countries. Nominal prices are weakly related across countries, but developments in France tend lead those in the other countries.

The analysis of the European Monetary Union period clearly shows stronger GDP linkages across countries than in the whole sample, against a background of increasing importance of trade flows. Stronger relationships are also seen for residential investment variables in the period with a common monetary policy, probably due to convergence in mortgage interest rates. Against this background, comovements in the housing sector continue to be much weaker for prices than for real variables.

[11] Recent work in Europe includes Álvarez and Cabrero (2009a), Bulligan (2009), Ferrara and Vigna (2009), Ferrara and Koopman (2009) or Knetsch (2009).

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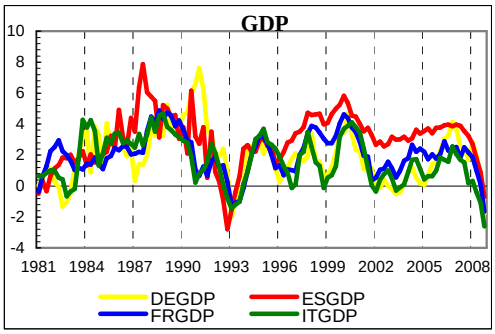
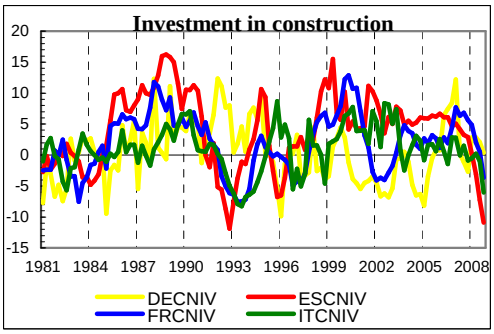
Appendix 1: Description of the 10 variables included in the dataset

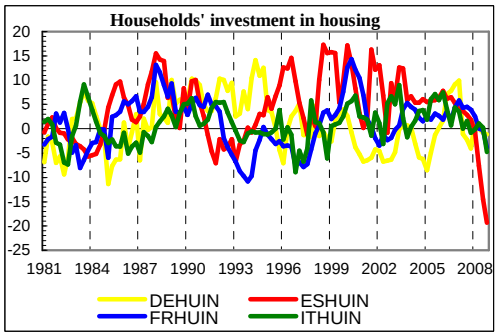
	Germany (DE)	Spain (ES)	France (FR)	Italy (IT)
GDP	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**
	Source: National Statistical Institute (Destatis)	**Source:** National Statistical Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Linked in 1991. Index 2000=100	**Comment**: Linkage of 1995 and 2000 quarterly national accounts bases. Index 2000=100	**Comment**: Chain-linked quarterly national accounts (SA-WDA, Base: 2000)	**Comment**: source QNA base year 2000
Investment in construction	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**
	Source: National Accounts, National Statistical Institute (Destatis). Index 2000=100	**Source:** National Statistic Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Linked in 1991. Index 2000=100	**Comment**: Linked on national accounts bases 1995 (since 1980 to 1994:Q4) and 2000, using q-o-q growth rates. Index 2000=100	**Comment**: Chain-linked quarterly national accounts (SA-WDA, Base: 2000)	**Comment**: source QNA base year 2000
Households' investment in housing (Volume)	**1980-Q1 2008-Q1**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**
	Source: National Accounts, National Statistical Institute (Destatis)	**Source:** National Statistical Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Linked in 1991. Before 1991 housing of total economy, then households' investment in housing. Index 2000=100	**Comment**: Linkage of 1995 and 2000 quarterly national accounts bases. Index 2000=100	**Comment**: Chain-linked quarterly national accounts (SA-WDA, Base: 2000)	**Comment**: source QNA base year 2000
Non residential construction investment	**1980-Q1 2008-Q1**	**1980-Q1 2008-Q4**	**1980-Q2 2008-Q4**	**1981-Q1 2008-Q4**
	Source: National Accounts, National Statistical Institute (Destatis)	**Source:** National Statistical Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Linked in 1991. Index 2000=100	**Comment**: Linkage of 1995 and 2000 quarterly national accounts bases. Index 2000=100	**Comment**: Chain-linked quarterly national accounts (SA-WDA, Base: 2000)	**Comment**: source QNA base year 2000
Construction Value added	**1980-Q1 2008-Q1**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1981-Q1 2008-Q4**
	Source: National Accounts, National Statistical Institute (Destatis)	**Source:** National Statistical Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Linked in 1991. Index 2000=100	**Comment**: Linkage of 1995 and 2000 quarterly national accounts bases. Index 2000=100	**Comment**: Chain-linked quarterly national accounts (SA-WDA, Base: 2000)	**Comment**: source QNA base year 2000
Employment in construction sector	**1980-Q1 2008-Q1**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q1**
	Source: National Accounts, National Statistical Institute (Destatis)	**Source:** National Statistical Institute (INE) and own elaboration	**Source:** National Statistical Institute (INSEE)	**Source:** National Statistical Institute (ISTAT)
	Comment: Thousands of people (Heads; cycle is the same as for full time equivalents, which are estimated, however)	**Comment:** Linkage of Labour Force Survay (up to 1994:Q4) to quarterly national account data. Thousands of people (Full Time Equivalent)	**Comment**: SA data	**Comment**: source QNA base year 2000
Authorizations (building permits)	**1980-Q1 2008-Q1**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	
	Source: National Statistical Institute (Destatis)	**Source:** Architects and Technical Architects´ Associations and own elaboration	**Source:** Ministère de l'Ecologie, de l'Energie, du Dévelopement Durable et de la Mer. Commissariat général au développement durable	
	Comment: Number of permits. Before 1994 West-Germany. Data multiplied by ratio 1994Q2 / 1994Q1.	**Comment**: Number of permits	**Comment**: Number of permits	
Housing starts		**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	
		Source: Housing Ministry	**Source:** Ministère de l'Ecologie, de l'Energie, du Dévelopement Durable et de la Mer. Commissariat général au développement durable	
		Comments: Includes subsidized and unsubsidized houses. Numbers of houses	**Comments**: Includes subsidized and unsubsidized houses. Number of houses	
House prices	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**
	Source: BulwienGesa AG and own calculations	**Source**: Housing Ministry and own elaboration	**Source**: Index Insee-Notaries since 1996 Q1 and internal back-calculation	**Source:** Il consulente Immobiliare and own calculation
	Comment: Yearly data. Quarterly data imputed. Index 2005=100	**Comment**: € per square meter. Own elaboration from 1983:Q4 BdE elaboration. Since 1987:Q1, Ministry of Housing, likening bases 2000 (until 2005:Q4) and 2005 since 2005:Q1, series linked using q-o-q growth rates	**Comment**: Price index of existing dwellings in France, SA, base 100 in 2000 Q4. Back-calculation using annual historiacl series.	**Comment**: € per square meter.Index 1995=100
Real house prices	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**	**1980-Q1 2008-Q4**
	Source: Own elaboration	**Source**: Own elaboration	**Source**: Own elaboration	**Source**: Own elaboration
	Comment: Ratio of house prices and CPI	**Comment**: Ratio of house prices and HICP	**Comment**: Ratio of house prices and HICP	**Comment**: Ratio of house prices and HICP

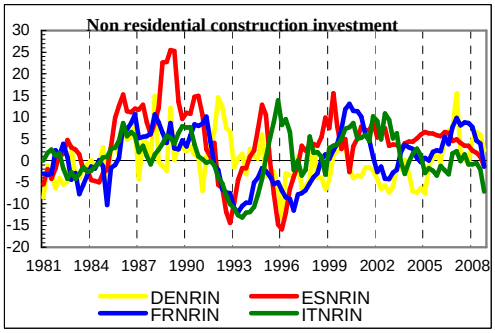
Unavailable or incomplete time range

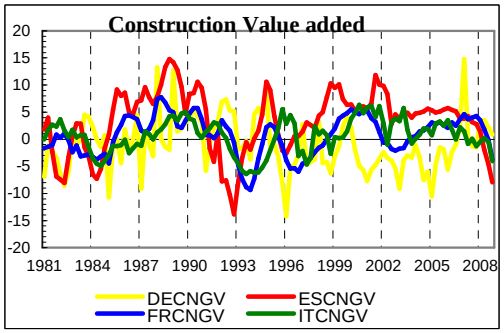
Appendix 2: Annual growth rates of the 10 variables (1980-2008)

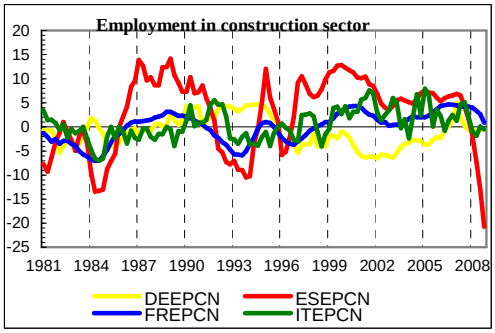


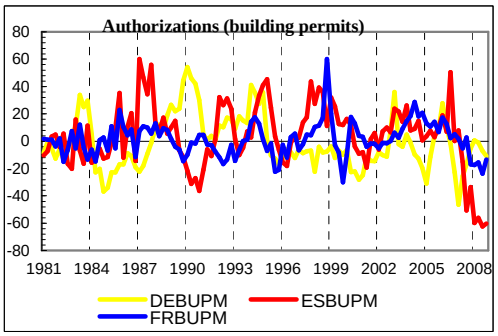


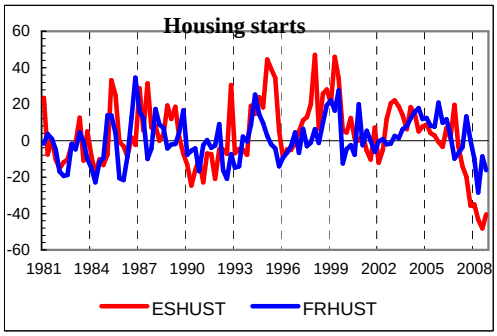


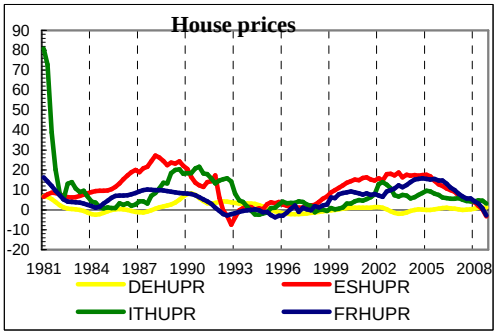


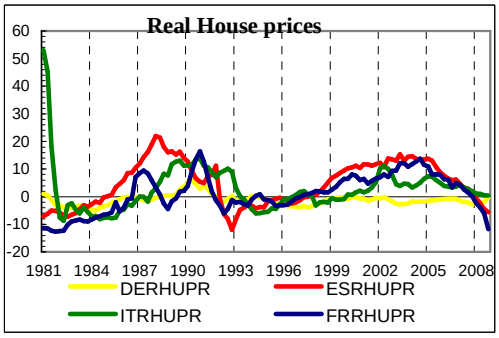




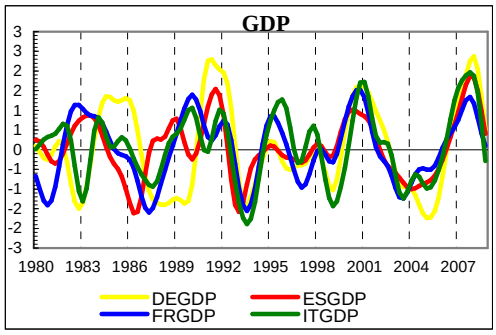


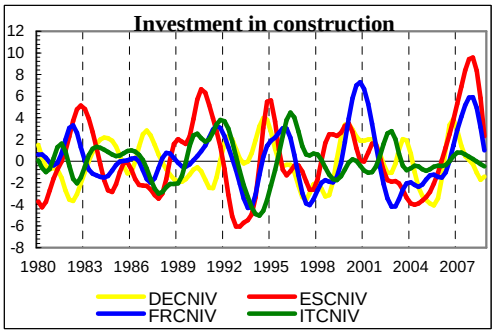


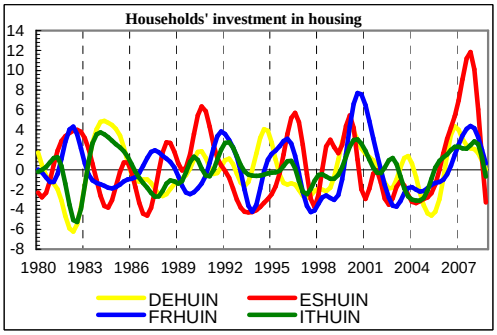


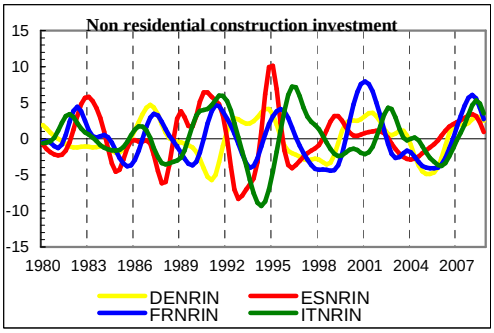


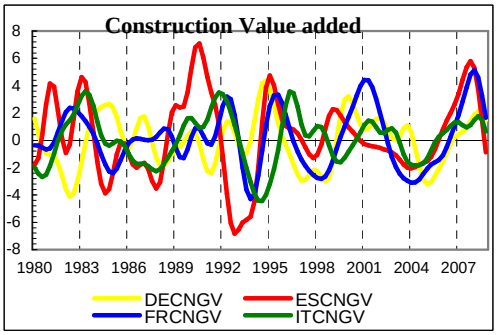
Appendix 3: Estimated growth cycles for the 10 variables (1980-2008)

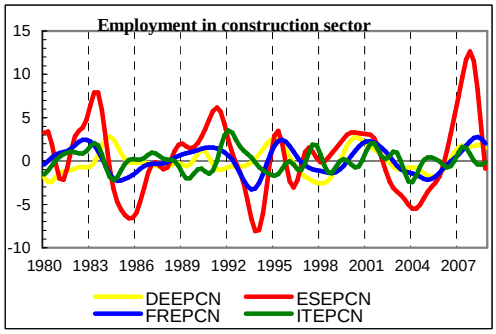


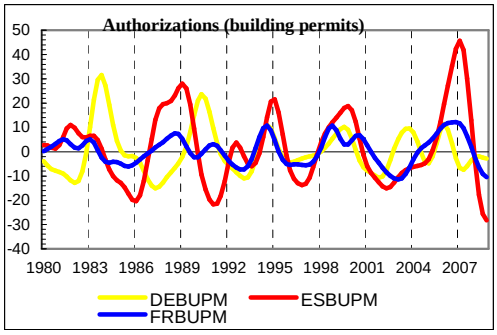


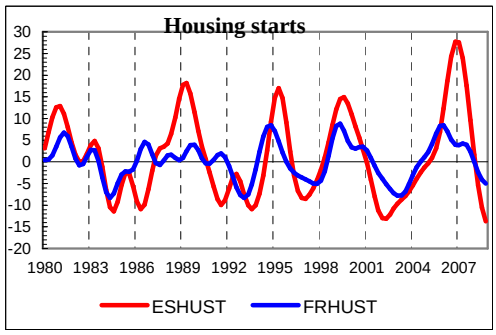


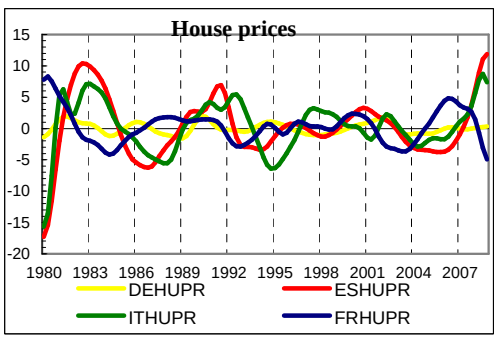


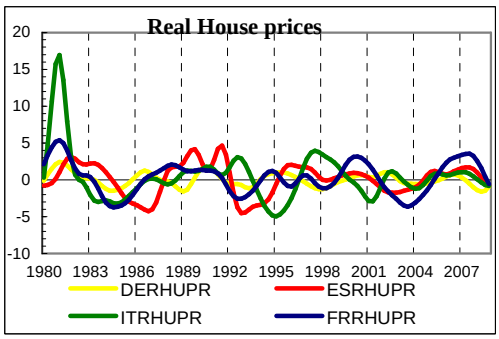












Appendix 4: Cross-correlation (1980:Q1 2008:Q4)

GDP

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.47	0.47	0.65
ES	0.47	1.00	0.66	0.58
FR	0.47	0.66	1.00	0.66
IT	0.65	0.58	0.66	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.95	0.35	0.35	0.58
ES	0.55	0.94	0.70	0.63
FR	0.54	0.59	0.95	0.63
IT	0.65	0.47	0.60	0.91

Lead /lag 2

	DE	ES	FR	IT
DE	0.81	0.20	0.19	0.44
ES	0.57	0.78	0.69	0.63
FR	0.57	0.49	0.80	0.53
IT	0.57	0.33	0.45	0.70

Lead /lag 4

	DE	ES	FR	IT
DE	0.40	-0.12	-0.18	0.02
ES	0.51	0.34	0.52	0.48
FR	0.58	0.28	0.35	0.28
IT	0.32	0.08	0.04	0.16

Investment in construction

Contemporaneous

	DE	ES	FR	IT
DE	1.00	-0.01	0.21	-0.16
ES	-0.01	1.00	0.60	0.10
FR	0.21	0.60	1.00	0.15
IT	-0.16	0.10	0.15	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	-0.02	0.29	-0.14
ES	0.01	0.94	0.63	0.24
FR	0.12	0.54	0.94	0.22
IT	-0.19	-0.03	0.06	0.93

Lead /lag 2

	DE	ES	FR	IT
DE	0.66	-0.05	0.33	-0.13
ES	0.03	0.79	0.62	0.37
FR	0.05	0.42	0.77	0.28
IT	-0.21	-0.15	-0.04	0.73

Lead /lag 4

	DE	ES	FR	IT
DE	0.10	-0.14	0.28	-0.10
ES	0.11	0.39	0.51	0.60
FR	-0.02	0.10	0.28	0.35
IT	-0.19	-0.34	-0.26	0.22

Households' investment in housing

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.08	0.14	0.71
ES	0.08	1.00	0.42	0.18
FR	0.14	0.42	1.00	0.22
IT	0.71	0.18	0.22	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	0.05	0.23	0.68
ES	0.10	0.92	0.45	0.19
FR	0.03	0.34	0.93	0.18
IT	0.67	0.14	0.25	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.74	0.01	0.31	0.59
ES	0.11	0.71	0.44	0.19
FR	-0.05	0.23	0.76	0.14
IT	0.57	0.09	0.26	0.70

Lead /lag 4

	DE	ES	FR	IT
DE	0.23	-0.07	0.33	0.33
ES	0.14	0.27	0.33	0.24
FR	-0.12	-0.02	0.23	0.11
IT	0.25	-0.03	0.20	0.19

Non residential construction investment

Contemporaneous

	DE	ES	FR	IT
DE	1.00	-0.08	0.45	-0.29
ES	-0.08	1.00	0.32	0.07
FR	0.45	0.32	1.00	0.26
IT	-0.29	0.07	0.26	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.95	-0.12	0.46	-0.27
ES	-0.05	0.91	0.42	0.23
FR	0.40	0.19	0.95	0.33
IT	-0.30	-0.09	0.17	0.95

Lead /lag 2

	DE	ES	FR	IT
DE	0.82	-0.15	0.45	-0.23
ES	-0.04	0.68	0.48	0.38
FR	0.34	0.03	0.79	0.37
IT	-0.30	-0.22	0.06	0.81

Lead /lag 4

	DE	ES	FR	IT
DE	0.44	-0.14	0.34	-0.13
ES	-0.06	0.08	0.47	0.58
FR	0.18	-0.24	0.31	0.35
IT	-0.26	-0.37	-0.18	0.35

Construction Value added

Contemporaneous

	DE	ES	FR	IT
DE	1.00	-0.02	0.29	-0.25
ES	-0.02	1.00	0.39	0.29
FR	0.29	0.39	1.00	0.41
IT	-0.25	0.29	0.41	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.92	-0.06	0.30	-0.27
ES	0.02	0.93	0.49	0.44
FR	0.24	0.26	0.94	0.49
IT	-0.20	0.12	0.29	0.95

Lead /lag 2

	DE	ES	FR	IT
DE	0.72	-0.11	0.28	-0.27
ES	0.02	0.74	0.54	0.58
FR	0.17	0.12	0.78	0.54
IT	-0.14	-0.04	0.14	0.80

Lead /lag 4

	DE	ES	FR	IT
DE	0.22	-0.18	0.15	-0.22
ES	-0.05	0.29	0.49	0.74
FR	0.06	-0.14	0.29	0.51
IT	0.03	-0.28	-0.17	0.36

Employment in construction sector

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.28	0.36	-0.18
ES	0.28	1.00	0.73	0.25
FR	0.36	0.73	1.00	0.18
IT	-0.18	0.25	0.18	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.95	0.23	0.39	-0.20
ES	0.32	0.94	0.73	0.28
FR	0.30	0.70	0.96	0.25
IT	-0.15	0.21	0.10	0.88

Lead /lag 2

	DE	ES	FR	IT
DE	0.83	0.16	0.39	-0.18
ES	0.34	0.79	0.65	0.27
FR	0.21	0.62	0.85	0.30
IT	-0.09	0.14	0.00	0.57

Lead /lag 4

	DE	ES	FR	IT
DE	0.43	-0.03	0.31	-0.04
ES	0.28	0.39	0.38	0.21
FR	-0.01	0.34	0.46	0.30
IT	0.03	-0.05	-0.18	-0.02

Building permits

Contemporaneous

	DE	ES	FR	IT
DE	1.00	-0.04	0.06	
ES	-0.04	1.00	0.74	
FR	0.06	0.74	1.00	
IT				

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	-0.08	0.04	
ES	0.01	0.94	0.64	
FR	0.06	0.77	0.94	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE	0.74	-0.13	0.02	
ES	0.06	0.78	0.51	
FR	0.06	0.74	0.77	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE	0.20	-0.23	-0.05	
ES	0.16	0.29	0.21	
FR	0.03	0.49	0.30	
IT				

Housing starts

Contemporaneous

	DE	ES	FR	IT
DE				
ES		1.00	0.70	
FR		0.70	1.00	
IT				

Lead /lag 1

	DE	ES	FR	IT
DE				
ES		0.94	0.61	
FR		0.73	0.92	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE				
ES		0.79	0.49	
FR		0.69	0.72	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE				
ES		0.33	0.22	
FR		0.45	0.22	
IT				

House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.30	0.06	0.19
ES	0.30	1.00	-0.41	0.79
FR	0.06	-0.41	1.00	-0.41
IT	0.19	0.79	-0.41	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	0.36	-0.03	0.18
ES	0.19	0.96	-0.52	0.75
FR	0.19	-0.19	0.97	-0.20
IT	0.12	0.75	-0.49	0.94

Lead /lag 2

	DE	ES	FR	IT
DE	0.75	0.40	-0.13	0.14
ES	0.08	0.85	-0.60	0.65
FR	0.29	0.06	0.87	0.05
IT	0.04	0.65	-0.54	0.77

Lead /lag 4

	DE	ES	FR	IT
DE	0.22	0.40	-0.35	0.09
ES	-0.09	0.47	-0.70	0.46
FR	0.37	0.47	0.56	0.40
IT	-0.09	0.33	-0.58	0.37

Real House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.10	0.51	0.32
ES	0.10	1.00	0.43	0.15
FR	0.51	0.43	1.00	0.45
IT	0.32	0.15	0.45	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	0.19	0.49	0.28
ES	0.01	0.95	0.33	0.13
FR	0.49	0.52	0.97	0.42
IT	0.31	0.18	0.44	0.93

Lead /lag 2

	DE	ES	FR	IT
DE	0.75	0.27	0.42	0.21
ES	-0.06	0.82	0.21	0.13
FR	0.42	0.57	0.87	0.36
IT	0.26	0.22	0.41	0.75

Lead /lag 4

	DE	ES	FR	IT
DE	0.24	0.37	0.17	0.09
ES	-0.16	0.47	0.00	0.22
FR	0.23	0.59	0.57	0.24
IT	0.13	0.25	0.31	0.36

Appendix 5: Maximal cross-correlation (1980:Q1 2008:Q4)

GDP

	DE	ES	FR	IT
DE	1.00	0.47	0.47	0.65
ES	0.57	1.00	0.70	0.63
FR	0.58	0.66	1.00	0.66
IT	0.65	0.58	0.66	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	Lead 2	contemp.	Lead 1	Lead 2
FR	Lead 4	contemp.	contemp.	contemp.
IT	contemp.	contemp.	contemp.	contemp.

Country row leads/lags country column

	DE	ES	FR	IT
DE	---	Lag	Lag	contemp.
ES	Lead	---	Lead	Lead
FR	Lead	Lag	---	Contemp.
IT	Contemp.	Lag	Contemp.	---

Investment in construction

	DE	ES	FR	IT
DE	1.00	-0.01	0.33	-0.10
ES	0.11	1.00	0.63	0.60
FR	0.21	0.60	1.00	0.35
IT	-0.16	0.10	0.15	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 2	Lead 4
ES	Lead 4	contemp.	Lead 1	Lead 4
FR	contemp.	contemp.	contemp.	Lead 4
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	Lead
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lag	Lag	Lag	---

Households' investment in housing

	DE	ES	FR	IT
DE	1.00	0.08	0.33	0.71
ES	0.14	1.00	0.45	0.24
FR	0.14	0.42	1.00	0.22
IT	0.71	0.18	0.26	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 4	contemp.
ES	Lead 4	contemp.	Lead 1	Lead 4
FR	contemp.	contemp.	contemp.	contemp.
IT	contemp.	contemp.	Lead 2	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	contemp.
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lag
IT	Contemp.	Lag	Lead	---

Non residential construction investment

	DE	ES	FR	IT
DE	1.00	-0.08	0.46	-0.13
ES	-0.04	1.00	0.48	0.58
FR	0.45	0.32	1.00	0.37
IT	-0.26	0.07	0.26	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 2	contemp.	Lead 2	Lead 4
FR	contemp.	contemp.	contemp.	Lead 2
IT	Lead 4	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	Lead
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lag	Lag	Lag	---

Construction Value added

	DE	ES	FR	IT
DE	1.00	-0.02	0.30	-0.22
ES	0.02	1.00	0.54	0.74
FR	0.29	0.39	1.00	0.54
IT	0.03	0.29	0.41	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 2	contemp.	Lead 2	Lead 4
FR	contemp.	contemp.	contemp.	Lead 2
IT	Lead 4	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	Lag
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lead	Lag	Lag	---

Employment in construction sector

	DE	ES	FR	IT
DE	1.00	0.28	0.39	-0.04
ES	0.34	1.00	0.73	0.28
FR	0.36	0.73	1.00	0.30
IT	0.03	0.25	0.18	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 2	contemp.	contemp.	Lead 1
FR	contemp.	contemp.	contemp.	Lead 4
IT	Lead 4	contemp.	contemp.	contemp.

Country column on country row

	DE	ES	FR	IT
DE	---	Lag	Lead	Lag
ES	Lead	---	Contemp.	Lead
FR	Lag	Contemp.	---	Lead
IT	Lead	Lag	Lag	---

Building permits

	DE	ES	FR	IT
DE	1.00	-0.04	0.06	
ES	0.16	1.00	0.74	
FR	0.06	0.77	1.00	
IT				

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	#N/A
ES	Lead 4	contemp.	contemp.	#N/A
FR	Lead 1	Lead 1	contemp.	#N/A
IT	#N/A	#N/A	#N/A	#N/A

	DE	ES	FR	IT
DE	---	Lag	Lag	
ES	Lead	---	Lag	
FR	Lead	Lead	---	
IT				

Housing starts

	DE	ES	FR	IT
DE				
ES		1.00	0.70	
FR		0.73	1.00	
IT				

	DE	ES	FR	IT
DE	#N/A	#N/A	#N/A	#N/A
ES	#N/A	contemp.	contemp.	#N/A
FR	#N/A	Lead 1	contemp.	#N/A
IT	#N/A	#N/A	#N/A	#N/A

	DE	ES	FR	IT
DE				
ES		---	Lag	
FR		Lead	---	
IT				

House prices

	DE	ES	FR	IT
DE	1.00	0.40	0.06	0.19
ES	0.30	1.00	-0.41	0.79
FR	0.37	0.47	1.00	0.40
IT	0.19	0.79	-0.41	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 2	contemp.	contemp.
ES	contemp.	contemp.	contemp.	contemp.
FR	Lead 4	Lead 4	contemp.	Lead 4
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	Lag	contemp.
ES	Lag	---	Lag	Contemp.
FR	Lead	Lead	---	Lead
IT	Contemp.	Contemp.	Lag	---

Real House prices

	DE	ES	FR	IT
DE	1.00	0.37	0.51	0.32
ES	0.10	1.00	0.43	0.22
FR	0.51	0.59	1.00	0.45
IT	0.32	0.25	0.45	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 4	contemp.	contemp.
ES	contemp.	contemp.	contemp.	Lead 4
FR	contemp.	Lead 4	contemp.	contemp.
IT	contemp.	Lead 4	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	contemp.	contemp.
ES	Lag	---	Lag	Lag
FR	Contemp.	Lead	---	Contemp.
IT	Contemp.	Lead	Contemp.	---

Appendix 6: Cross-correlation (1999:Q1 2008:Q4)

GDP

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.93	0.85	0.92
ES	0.93	1.00	0.92	0.85
FR	0.85	0.92	1.00	0.85
IT	0.92	0.85	0.85	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.96	0.84	0.72	0.86
ES	0.95	0.96	0.85	0.84
FR	0.91	0.92	0.95	0.89
IT	0.89	0.80	0.71	0.93

Lead /lag 2

	DE	ES	FR	IT
DE	0.84	0.70	0.54	0.73
ES	0.92	0.87	0.74	0.78
FR	0.89	0.85	0.83	0.85
IT	0.78	0.69	0.51	0.77

Lead /lag 4

	DE	ES	FR	IT
DE	0.53	0.37	0.14	0.33
ES	0.74	0.61	0.46	0.55
FR	0.74	0.62	0.48	0.60
IT	0.51	0.40	0.11	0.34

Investment in construction

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.32	0.44	0.03
ES	0.32	1.00	0.69	0.06
FR	0.44	0.69	1.00	-0.15
IT	0.03	0.06	-0.15	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.88	0.34	0.54	0.11
ES	0.30	0.96	0.70	0.09
FR	0.29	0.64	0.94	-0.16
IT	-0.05	0.04	-0.16	0.87

Lead /lag 2

	DE	ES	FR	IT
DE	0.58	0.31	0.57	0.18
ES	0.26	0.87	0.69	0.12
FR	0.17	0.56	0.80	-0.14
IT	-0.03	0.01	-0.17	0.54

Lead /lag 4

	DE	ES	FR	IT
DE	-0.03	0.18	0.40	0.13
ES	0.22	0.64	0.62	0.16
FR	0.09	0.36	0.36	0.10
IT	0.05	-0.09	-0.20	-0.19

Households' investment in housing

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.64	0.63	0.60
ES	0.64	1.00	0.48	0.66
FR	0.63	0.48	1.00	0.71
IT	0.60	0.66	0.71	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.91	0.56	0.74	0.51
ES	0.65	0.92	0.60	0.68
FR	0.46	0.33	0.94	0.62
IT	0.64	0.57	0.73	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.69	0.43	0.77	0.41
ES	0.59	0.72	0.65	0.65
FR	0.29	0.17	0.78	0.49
IT	0.67	0.47	0.69	0.74

Lead /lag 4

	DE	ES	FR	IT
DE	0.14	0.12	0.58	0.20
ES	0.44	0.39	0.63	0.50
FR	0.05	-0.05	0.30	0.24
IT	0.62	0.30	0.50	0.33

Non residential construction investment

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.51	0.83	0.42
ES	0.51	1.00	0.47	0.15
FR	0.83	0.47	1.00	0.31
IT	0.42	0.15	0.31	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.95	0.39	0.83	0.54
ES	0.67	0.96	0.56	0.32
FR	0.77	0.45	0.95	0.44
IT	0.28	-0.01	0.16	0.95

Lead /lag 2

	DE	ES	FR	IT
DE	0.82	0.27	0.77	0.63
ES	0.78	0.87	0.63	0.44
FR	0.67	0.40	0.83	0.53
IT	0.13	-0.20	-0.01	0.80

Lead /lag 4

	DE	ES	FR	IT
DE	0.48	-0.02	0.49	0.69
ES	0.87	0.60	0.75	0.57
FR	0.47	0.18	0.41	0.62
IT	-0.18	-0.61	-0.33	0.32

Construction Value added

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.31	0.62	0.30
ES	0.31	1.00	0.62	0.48
FR	0.62	0.62	1.00	0.72
IT	0.30	0.48	0.72	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.92	0.15	0.56	0.25
ES	0.50	0.95	0.72	0.53
FR	0.64	0.51	0.96	0.77
IT	0.34	0.44	0.62	0.94

Lead /lag 2

	DE	ES	FR	IT
DE	0.72	-0.01	0.48	0.18
ES	0.62	0.82	0.75	0.55
FR	0.64	0.37	0.86	0.76
IT	0.41	0.41	0.51	0.80

Lead /lag 4

	DE	ES	FR	IT
DE	0.33	-0.32	0.28	0.03
ES	0.73	0.55	0.74	0.54
FR	0.65	0.09	0.55	0.61
IT	0.55	0.32	0.25	0.41

Employment in construction sector

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.76	0.87	0.29
ES	0.76	1.00	0.72	0.43
FR	0.87	0.72	1.00	0.45
IT	0.29	0.43	0.45	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.96	0.68	0.92	0.35
ES	0.82	0.95	0.86	0.39
FR	0.76	0.58	0.97	0.44
IT	0.22	0.44	0.46	0.82

Lead /lag 2

	DE	ES	FR	IT
DE	0.84	0.58	0.92	0.43
ES	0.81	0.83	0.91	0.33
FR	0.62	0.43	0.89	0.44
IT	0.19	0.36	0.46	0.40

Lead /lag 4

	DE	ES	FR	IT
DE	0.52	0.26	0.76	0.49
ES	0.74	0.55	0.89	0.27
FR	0.30	0.07	0.58	0.34
IT	0.18	0.04	0.38	-0.26

Building permits

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.19	0.10	
ES	0.19	1.00	0.85	
FR	0.10	0.85	1.00	
IT				

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	0.32	0.26	
ES	0.04	0.95	0.79	
FR	-0.08	0.83	0.96	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE	0.62	0.43	0.43	
ES	-0.13	0.78	0.66	
FR	-0.24	0.76	0.84	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE	-0.12	0.52	0.67	
ES	-0.41	0.26	0.26	
FR	-0.46	0.49	0.47	
IT				

Housing starts

Contemporaneous

	DE	ES	FR	IT
DE				
ES		1.00	0.80	
FR		0.80	1.00	
IT				

Lead /lag 1

	DE	ES	FR	IT
DE				
ES		0.96	0.75	
FR		0.81	0.96	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE				
ES		0.83	0.67	
FR		0.77	0.85	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE				
ES		0.42	0.39	
FR		0.58	0.52	
IT				

House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.47	-0.05	0.26
ES	0.47	1.00	-0.26	0.86
FR	-0.05	-0.26	1.00	-0.23
IT	0.26	0.86	-0.23	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.95	0.42	-0.21	0.29
ES	0.53	0.98	-0.39	0.78
FR	0.13	0.00	0.95	0.02
IT	0.22	0.87	-0.34	0.96

Lead /lag 2

	DE	ES	FR	IT
DE	0.81	0.35	-0.36	0.28
ES	0.60	0.91	-0.51	0.67
FR	0.29	0.25	0.82	0.26
IT	0.17	0.84	-0.41	0.85

Lead /lag 4

	DE	ES	FR	IT
DE	0.40	0.20	-0.62	0.19
ES	0.63	0.58	-0.72	0.31
FR	0.53	0.58	0.48	0.58
IT	0.04	0.66	-0.52	0.48

Real House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	-0.06	0.19	0.02
ES	-0.06	1.00	0.85	0.24
FR	0.19	0.85	1.00	0.09
IT	0.02	0.24	0.09	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	-0.07	0.18	0.10
ES	-0.08	0.96	0.92	0.15
FR	0.17	0.72	0.97	0.00
IT	-0.11	0.31	0.19	0.91

Lead /lag 2

	DE	ES	FR	IT
DE	0.76	-0.10	0.14	0.11
ES	-0.07	0.84	0.93	0.06
FR	0.14	0.56	0.88	-0.08
IT	-0.25	0.37	0.28	0.65

Lead /lag 4

	DE	ES	FR	IT
DE	0.21	-0.31	-0.09	-0.04
ES	0.04	0.53	0.84	-0.03
FR	0.08	0.19	0.61	-0.18
IT	-0.44	0.44	0.39	-0.03

Appendix 7: Maximal cross-correlation (1999:Q1 2008:Q4)

GDP

	DE	ES	FR	IT
DE	1.00	0.93	0.85	0.92
ES	0.95	1.00	0.92	0.85
FR	0.91	0.92	1.00	0.89
IT	0.92	0.85	0.85	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	Lead 1	contemp.	contemp.	contemp.
FR	Lead 1	contemp.	contemp.	Lead 1
IT	contemp.	contemp.	contemp.	contemp.

Country row leads/lags country column

	DE	ES	FR	IT
DE	---	Lag	Lag	contemp.
ES	Lead	---	Contemp.	Contemp.
FR	Lead	Contemp.	---	Lead
IT	Contemp.	Contemp.	Lag	---

Investment in construction

	DE	ES	FR	IT
DE	1.00	0.34	0.57	0.18
ES	0.32	1.00	0.70	0.16
FR	0.44	0.69	1.00	0.10
IT	0.05	0.06	-0.15	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 1	Lead 2	Lead 2
ES	contemp.	contemp.	Lead 1	Lead 4
FR	contemp.	contemp.	contemp.	Lead 4
IT	Lead 4	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	Lead	Lead
ES	Lag	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lag	Lag	Lag	---

Households' investment in housing

	DE	ES	FR	IT
DE	1.00	0.64	0.77	0.60
ES	0.65	1.00	0.65	0.68
FR	0.63	0.48	1.00	0.71
IT	0.67	0.66	0.73	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 2	contemp.
ES	Lead 1	contemp.	Lead 2	Lead 1
FR	contemp.	contemp.	contemp.	contemp.
IT	Lead 2	contemp.	Lead 1	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	Lag
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lag
IT	Lead	Lag	Lead	---

Non residential construction investment

	DE	ES	FR	IT
DE	1.00	0.51	0.83	0.69
ES	0.87	1.00	0.75	0.57
FR	0.83	0.47	1.00	0.62
IT	0.42	0.15	0.31	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 4	contemp.	Lead 4	Lead 4
FR	contemp.	contemp.	contemp.	Lead 4
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lead	Lead
ES	Lead	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lag	Lag	Lag	---

Construction Value added

	DE	ES	FR	IT
DE	1.00	0.31	0.62	0.30
ES	0.73	1.00	0.75	0.55
FR	0.65	0.62	1.00	0.77
IT	0.55	0.48	0.72	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	Lead 4	contemp.	Lead 2	Lead 2
FR	Lead 4	contemp.	contemp.	Lead 1
IT	Lead 4	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lag	Lag
ES	Lead	---	Lead	Lead
FR	Lead	Lag	---	Lead
IT	Lead	Lag	Lag	---

Employment in construction sector

	DE	ES	FR	IT
DE	1.00	0.76	0.92	0.49
ES	0.82	1.00	0.91	0.43
FR	0.87	0.72	1.00	0.45
IT	0.29	0.44	0.46	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 1	contemp.	Lead 2	contemp.
FR	contemp.	contemp.	contemp.	contemp.
IT	contemp.	Lead 1	Lead 2	contemp.

Country column on country row

	DE	ES	FR	IT
DE	---	Lag	Lead	Lead
ES	Lead	---	Lead	Lag
FR	Lag	Lag	---	Lag
IT	Lag	Lead	Lead	---

Building permits

	DE	ES	FR	IT
DE	1.00	0.52	0.67	
ES	0.19	1.00	0.85	
FR	0.10	0.85	1.00	
IT				

	DE	ES	FR	IT
DE	contemp.	Lead 4	Lead 4	
ES	contemp.	contemp.	contemp.	
FR	contemp.	contemp.	contemp.	
IT				

	DE	ES	FR	IT
DE	---	Lead	Lead	
ES	Lag	---	Contemp.	
FR	Lag	Contemp.	---	
IT				

Housing starts

	DE	ES	FR	IT
DE				
ES		1.00	0.80	
FR		0.81	1.00	
IT				

	DE	ES	FR	IT
DE				
ES		contemp.	contemp.	
FR		Lead 1	contemp.	
IT				

	DE	ES	FR	IT
DE				
ES		---	Lag	
FR		Lead	---	
IT				

House prices

	DE	ES	FR	IT
DE	1.00	0.47	-0.05	0.29
ES	0.63	1.00	-0.26	0.86
FR	0.53	0.58	1.00	0.58
IT	0.26	0.87	-0.23	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	Lead 1
ES	Lead 4	contemp.	contemp.	contemp.
FR	Lead 4	Lead 4	contemp.	Lead 4
IT	contemp.	Lead 1	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lag	Lead
ES	Lead	---	Lag	Lag
FR	Lead	Lead	---	Lead
IT	Lag	Lead	Lag	---

Real House prices

	DE	ES	FR	IT
DE	1.00	-0.06	0.19	0.11
ES	0.04	1.00	0.93	0.24
FR	0.19	0.85	1.00	0.09
IT	0.02	0.44	0.38	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	Lead 2
ES	Lead 4	contemp.	Lead 2	contemp.
FR	contemp.	contemp.	contemp.	contemp.
IT	contemp.	Lead 4	Lead 4	contemp.

	DE	ES	FR	IT
DE	---	Lag	contemp.	Lead
ES	Lead	---	Lead	Lag
FR	Contemp.	Lag	---	Lag
IT	Lag	Lead	Lead	---

Appendix 8: Concordance indexes (1980 Q1 - 2008 Q4)

GDP

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.58	0.69	0.72
ES	0.58	1.00	0.72	0.59
FR	0.69	0.72	1.00	0.73
IT	0.72	0.59	0.73	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	0.54	0.64	0.70
ES	0.62	0.93	0.70	0.57
FR	0.70	0.71	0.92	0.70
IT	0.58	0.59	0.69	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.81	0.48	0.58	0.64
ES	0.66	0.86	0.69	0.56
FR	0.70	0.71	0.84	0.66
IT	0.58	0.60	0.64	0.84

Lead /lag 4

	DE	ES	FR	IT
DE	0.62	0.39	0.46	0.50
ES	0.67	0.71	0.60	0.52
FR	0.71	0.67	0.68	0.56
IT	0.57	0.61	0.53	0.68

Investment in construction

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.55	0.38	0.36
ES	0.55	1.00	0.79	0.62
FR	0.38	0.79	1.00	0.67
IT	0.36	0.62	0.67	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.91	0.56	0.40	0.38
ES	0.53	0.92	0.78	0.64
FR	0.37	0.78	0.92	0.71
IT	0.34	0.57	0.64	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.82	0.56	0.44	0.40
ES	0.51	0.84	0.77	0.67
FR	0.37	0.75	0.84	0.74
IT	0.33	0.53	0.61	0.84

Lead /lag 4

	DE	ES	FR	IT
DE	0.64	0.55	0.50	0.46
ES	0.49	0.69	0.71	0.71
FR	0.37	0.63	0.69	0.71
IT	0.32	0.45	0.52	0.68

Households' investment in housing

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.64	0.45	0.68
ES	0.64	1.00	0.72	0.61
FR	0.45	0.72	1.00	0.58
IT	0.68	0.61	0.58	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	0.62	0.52	0.69
ES	0.60	0.92	0.71	0.65
FR	0.39	0.71	0.90	0.58
IT	0.66	0.58	0.57	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.79	0.61	0.58	0.68
ES	0.56	0.84	0.68	0.68
FR	0.33	0.67	0.81	0.59
IT	0.62	0.55	0.54	0.84

Lead /lag 4

	DE	ES	FR	IT
DE	0.57	0.55	0.62	0.63
ES	0.50	0.68	0.59	0.67
FR	0.30	0.55	0.61	0.56
IT	0.50	0.46	0.50	0.69

Non residential construction investment

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.50	0.68	0.58
ES	0.50	1.00	0.56	0.55
FR	0.68	0.56	1.00	0.70
IT	0.58	0.55	0.70	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.93	0.49	0.70	0.58
ES	0.50	0.89	0.60	0.61
FR	0.66	0.50	0.90	0.72
IT	0.54	0.50	0.67	0.90

Lead /lag 2

	DE	ES	FR	IT
DE	0.86	0.45	0.69	0.58
ES	0.47	0.77	0.64	0.62
FR	0.62	0.43	0.81	0.71
IT	0.51	0.45	0.64	0.80

Lead /lag 4

	DE	ES	FR	IT
DE	0.73	0.41	0.67	0.60
ES	0.47	0.54	0.68	0.62
FR	0.52	0.41	0.62	0.63
IT	0.47	0.39	0.54	0.61

Construction Value added

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.69	0.51	0.55
ES	0.69	1.00	0.61	0.57
FR	0.51	0.61	1.00	0.73
IT	0.55	0.57	0.73	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.91	0.69	0.50	0.54
ES	0.69	0.91	0.67	0.61
FR	0.54	0.54	0.92	0.79
IT	0.55	0.51	0.67	0.92

Lead /lag 2

	DE	ES	FR	IT
DE	0.82	0.67	0.50	0.53
ES	0.70	0.82	0.71	0.63
FR	0.54	0.46	0.84	0.80
IT	0.56	0.46	0.61	0.84

Lead /lag 4

	DE	ES	FR	IT
DE	0.66	0.62	0.51	0.55
ES	0.66	0.64	0.69	0.68
FR	0.54	0.41	0.69	0.79
IT	0.59	0.39	0.46	0.70

Employment in construction sector

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.59	0.67	0.40
ES	0.59	1.00	0.73	0.61
FR	0.67	0.73	1.00	0.60
IT	0.40	0.61	0.60	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.92	0.59	0.68	0.40
ES	0.60	0.93	0.72	0.60
FR	0.64	0.75	0.92	0.63
IT	0.42	0.63	0.57	0.90

Lead /lag 2

	DE	ES	FR	IT
DE	0.84	0.57	0.68	0.42
ES	0.62	0.86	0.69	0.59
FR	0.60	0.75	0.84	0.63
IT	0.44	0.62	0.53	0.81

Lead /lag 4

	DE	ES	FR	IT
DE	0.70	0.54	0.66	0.52
ES	0.62	0.71	0.58	0.54
FR	0.54	0.69	0.70	0.62
IT	0.54	0.58	0.46	0.61

Building permits

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.58	0.60	NA
ES	0.58	1.00	0.72	NA
FR	0.60	0.72	1.00	NA
IT	NA	NA	NA	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	0.60	0.59	
ES	0.56	0.92	0.70	
FR	0.58	0.74	0.90	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE	0.79	0.61	0.58	
ES	0.57	0.84	0.68	
FR	0.56	0.75	0.81	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE	0.59	0.56	0.54	
ES	0.60	0.68	0.62	
FR	0.55	0.65	0.61	
IT				

Housing starts

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.00	0.00	0.00
ES		1.00	0.72	0.00
FR		0.72	1.00	0.00
IT				1.00

Lead /lag 1

	DE	ES	FR	IT
DE				
ES		0.93	0.69	
FR		0.75	0.92	
IT				

Lead /lag 2

	DE	ES	FR	IT
DE				
ES		0.86	0.66	
FR		0.75	0.84	
IT				

Lead /lag 4

	DE	ES	FR	IT
DE				
ES		0.71	0.58	
FR		0.65	0.68	
IT				

House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.58	0.46	0.47
ES	0.58	1.00	0.55	0.70
FR	0.46	0.55	1.00	0.54
IT	0.47	0.70	0.54	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.91	0.61	0.49	0.50
ES	0.54	0.93	0.51	0.73
FR	0.44	0.59	0.92	0.55
IT	0.44	0.66	0.54	0.95

Lead /lag 2

	DE	ES	FR	IT
DE	0.82	0.64	0.52	0.53
ES	0.50	0.86	0.47	0.76
FR	0.43	0.63	0.84	0.55
IT	0.44	0.62	0.54	0.89

Lead /lag 4

	DE	ES	FR	IT
DE	0.64	0.69	0.54	0.55
ES	0.44	0.71	0.45	0.78
FR	0.44	0.59	0.68	0.60
IT	0.45	0.56	0.49	0.79

Real House prices

Contemporaneous

	DE	ES	FR	IT
DE	1.00	0.58	0.67	0.49
ES	0.58	1.00	0.63	0.53
FR	0.67	0.63	1.00	0.53
IT	0.49	0.53	0.53	1.00

Lead /lag 1

	DE	ES	FR	IT
DE	0.90	0.58	0.65	0.54
ES	0.57	0.92	0.61	0.55
FR	0.68	0.65	0.93	0.54
IT	0.44	0.54	0.52	0.93

Lead /lag 2

	DE	ES	FR	IT
DE	0.81	0.61	0.61	0.57
ES	0.55	0.84	0.55	0.56
FR	0.68	0.64	0.86	0.55
IT	0.41	0.54	0.52	0.86

Lead /lag 4

	DE	ES	FR	IT
DE	0.61	0.60	0.54	0.56
ES	0.49	0.68	0.44	0.59
FR	0.64	0.62	0.71	0.54
IT	0.38	0.57	0.51	0.71

Appendix 9: Maximal cross-concordance and leading degree (1980 Q1 - 2008 Q4)

GDP

	DE	ES	FR	IT
DE	1.00	0.58	0.69	0.72
ES	0.67	1.00	0.72	0.59
FR	0.71	0.72	1.00	0.73
IT	0.72	0.61	0.73	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	Lead 4	contemp.	contemp.	contemp.
FR	Lead 1	contemp.	contemp.	contemp.
IT	contemp.	Lead 4	contemp.	contemp.

Country row lead/lag country column

	DE	ES	FR	IT
DE	---	Lag	Lag	contemp.
ES	Lead	---	Contemp.	Lag
FR	Lead	Contemp.	---	Contemp.
IT	Contemp.	Lead	Contemp.	---

Investment in construction

	DE	ES	FR	IT
DE	1.00	0.56	0.50	0.46
ES	0.55	1.00	0.79	0.71
FR	0.38	0.79	1.00	0.74
IT	0.36	0.62	0.67	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 1	Lead 4	Lead 4
ES	contemp.	contemp.	contemp.	Lead 4
FR	contemp.	contemp.	contemp.	Lead 2
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	Lead	Lead
ES	Lag	---	Contemp.	Lead
FR	Lag	Contemp.	---	Lead
IT	Lag	Lag	Lag	---

Households' investment in housing

	DE	ES	FR	IT
DE	1.00	0.64	0.62	0.69
ES	0.64	1.00	0.72	0.68
FR	0.45	0.72	1.00	0.59
IT	0.68	0.61	0.58	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 1
ES	contemp.	contemp.	contemp.	Lead 2
FR	contemp.	contemp.	contemp.	Lead 2
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	contemp.	Lead	Lead
ES	Contemp.	---	Contemp.	Lead
FR	Lag	Contemp.	---	Lead
IT	Lag	Lag	Lag	---

Non residential construction investment

	DE	ES	FR	IT
DE	1.00	0.50	0.70	0.60
ES	0.50	1.00	0.68	0.62
FR	0.68	0.56	1.00	0.72
IT	0.58	0.55	0.70	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	contemp.	contemp.	Lead 4	Lead 2
FR	contemp.	contemp.	contemp.	Lead 1
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	contemp.	Lead	Lead
ES	Contemp.	---	Lead	Lead
FR	Lag	Lag	---	Lead
IT	Lag	Lag	Lag	---

Construction Value added

	DE	ES	FR	IT
DE	1.00	0.69	0.51	0.55
ES	0.70	1.00	0.71	0.68
FR	0.54	0.61	1.00	0.80
IT	0.59	0.57	0.73	1.00

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	Lead 2	contemp.	Lead 2	Lead 4
FR	Lead 1	contemp.	contemp.	Lead 2
IT	Lead 4	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lag	Lag	Lag
ES	Lead	---	Lead	Lead
FR	Lead	Lag	---	Lead
IT	Lead	Lag	Lag	---

Employment in construction sector

	DE	ES	FR	IT
DE	1.00	0.59	0.68	0.52
ES	0.62	1.00	0.73	0.61
FR	0.67	0.75	1.00	0.63
IT	0.54	0.63	0.60	1.00

Maxima correlation located in:

	DE	ES	FR	IT
DE	contemp.	contemp.	Lead 1	Lead 4
ES	Lead 2	contemp.	contemp.	contemp.
FR	contemp.	Lead 1	contemp.	Lead 1
IT	Lead 4	Lead 1	contemp.	contemp.

Country column on country row

	DE	ES	FR	IT
DE	---	Lag	Lead	Lag
ES	Lead	---	Lag	Lag
FR	Lag	Lead	---	Lead
IT	Lead	Lead	Lag	---

Building permits

	DE	ES	FR	IT
DE	1.00	0.61	0.60	
ES	0.60	1.00	0.72	
FR	0.60	0.75	1.00	
IT				

	DE	ES	FR	IT
DE	contemp.	Lead 2	contemp.	#N/A
ES	Lead 4	contemp.	contemp.	#N/A
FR	contemp.	Lead 2	contemp.	#N/A
IT	#N/A	#N/A	#N/A	#N/A

	DE	ES	FR	IT
DE	---	Lead	contemp.	
ES	Lag	---	Lag	
FR	Contemp.	Lead	---	
IT				

Housing starts

	DE	ES	FR	IT
DE				
ES		1.00	0.72	
FR		0.75	1.00	
IT				

	DE	ES	FR	IT
DE	contemp.	contemp.	contemp.	contemp.
ES	contemp.	contemp.	contemp.	contemp.
FR	contemp.	Lead 1	contemp.	contemp.
IT	#N/A	#N/A	#N/A	#N/A

	DE	ES	FR	IT
DE				
ES		---	Lag	
FR		Lead	---	
IT				

House prices

	DE	ES	FR	IT
DE	1.00	0.69	0.54	0.55
ES	0.58	1.00	0.55	0.78
FR	0.46	0.63	1.00	0.60
IT	0.47	0.70	0.54	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 4	Lead 4	Lead 4
ES	contemp.	contemp.	contemp.	Lead 4
FR	contemp.	Lead 2	contemp.	Lead 4
IT	contemp.	contemp.	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	Lead	Lead
ES	Lag	---	Lag	Lead
FR	Lag	Lead	---	Lead
IT	Lag	Lag	Lag	---

Real House prices

	DE	ES	FR	IT
DE	1.00	0.61	0.67	0.57
ES	0.58	1.00	0.63	0.59
FR	0.68	0.65	1.00	0.55
IT	0.49	0.57	0.53	1.00

	DE	ES	FR	IT
DE	contemp.	Lead 2	contemp.	Lead 2
ES	contemp.	contemp.	contemp.	Lead 4
FR	Lead 1	Lead 1	contemp.	Lead 2
IT	contemp.	Lead 4	contemp.	contemp.

	DE	ES	FR	IT
DE	---	Lead	Lag	Lead
ES	Lag	---	Lag	Lead
FR	Lead	Lead	---	Lead
IT	Lag	Lag	Lag	---