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EURO AREA COUNTRIES**

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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 1980q1 – 2008q4. Our main findings are that GDP cycles between 1.5 and 8 years show a high degree of comovement across these four countries, reflecting trade linkages. In contrast comovements in housing market cycles between 1.5 and 8 years are much weaker, idiosyncratic factors playing a major role. House prices are even less related across countries than quantities (residential investment, building permits, housing starts ...). We find however much stronger relationships since 1999, i.e. in the common monetary policy period.

Keywords: Housing cycles, synchronisation measures, euro area countries.

JEL codes: E32, R21, R32

Résumé:

Le récent éclatement de la bulle des prix de l'immobilier résidentiel aux Etats-Unis et ses effets de propagation sur les économies réelles à travers le monde ont remis en lumière le rôle du secteur immobilier dans le cycle économique. Dans ce papier, nous étudions les relations entre les cycles immobiliers des quatre principaux pays de la zone euro (Allemagne, France, Italie et Espagne) sur la période allant du premier trimestre 1980 au dernier trimestre 2008. Les principaux résultats établis montrent que les cycles du PIB entre 1,5 et 8 ans présentent un fort degré de co-mouvement au sein de ces pays, reflétant les échanges intra-zone. En revanche, les mouvements communs aux cycles entre 1,5 et 8 ans sur les différents marchés immobiliers sont moins marqués, les facteurs idiosyncratiques jouant un rôle majeur dans la dynamique des pays. Les résultats montrent également que les prix immobiliers sont moins synchronisés que les volumes (investissement résidentiel, permis de construire, mises en chantier ...). Nous trouvons cependant que les relations entre les différents cycles se sont intensifiées depuis la création de la zone monétaire commune en 1999.

Mots-clés: Cycles immobiliers, Synchronisation, Pays de la zone euro.

Codes JEL: E32, R21, R32

1. Introduction

The recent burst of the house price bubble in the United States and its spillover effects on real economies worldwide have reinforced the interest in the role of housing in the business cycle. Cross country analysis for the euro area is particularly needed to determine the relative importance of common versus idiosyncratic factors in housing markets and its interaction with the rest of the economy. Higher commonalities are to be expected in the European Monetary Union (EMU) period, given the existence of a common monetary policy. However, 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, which greatly differ across euro area countries¹. Other factors, such as the degree of home ownership, the availability of land or the regulatory framework, can also have an important impact on housing demand and supply decisions (Muellbauer and Murphy, 2008).

Existing empirical literature on housing markets mostly refers to Anglo-Saxon countries (particularly, the United States and the United Kingdom) and has emphasized the effects of house price movements on consumption and GDP through wealth channels. Even though housing market imbalances in Anglo-Saxon countries have been stronger than in European markets, cross country heterogeneity in price and volume developments raises two issues: firstly, the interaction between housing variables and the macroeconomy within each national economy and, secondly, the role of synchronization across countries of housing variables. Regarding the first issue, Ferrara and Vigna (2009) and Álvarez and Cabrero (2009) find, respectively for France and Spain, that current housing sector cycles are strongly correlated with future GDP cycles, in line with Leamer (2007) for the US. In contrast, Bulligan (2009) finds that house prices and residential investment lag Italian GDP. Knetsch (2009) analyses the impact of German unification on housing cycles and estimates long term relationships between residential investment and a set of variables such as household income, population and housing prices. The second issue is tackled in this paper and also in Ferrara and Koopman (2009).

Existing idiosyncrasies of housing markets suggests adopting a flexible enough methodological approach, capable of dealing with these differences. For this reason, we adopt nonparametric approaches to define the cycle (section 2) and date its turning points (section 3). 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 choice of concentrating on growth cycles rather than classical business cycles (defined as cycles in the level of a series) is dictated by the limited number of cycles in the latter. 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.

¹ See Mercer Oliver Wyman (2003), ECB (2003) and IMF (2008).

The analysis covers the period 1980q1-2008q4, 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. In the analysis, we include several construction related GDP components such as households' 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 explore relationships between the different variables by analysing cross-country pair-wise and multivariate comovement measures. Specifically, for each country pair, we compute cross-correlation coefficients and cross-concordance indexes and carry out a lead-lag analysis of turning points. We also consider two multivariate measures: effective dependence and average diffusion, defined in section 3. Our results are consistent with previous empirical analysis supporting a broadly common GDP growth cycle among the four major euro area countries, with the German cycle presenting 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. Nonetheless, the housing volume cycles in Germany and Italy are similar to each other, as are those in France and Spain, but there is no common volume cycle among all four countries. 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 price 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 a certain number of 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 six

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 long 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 twelve 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 rarely used for economic time series². 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

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

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 avoiding 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 tangent³ can be expressed in the time domain as symmetric, two sided filters in the lag (L) and forward (F) operators given by

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.

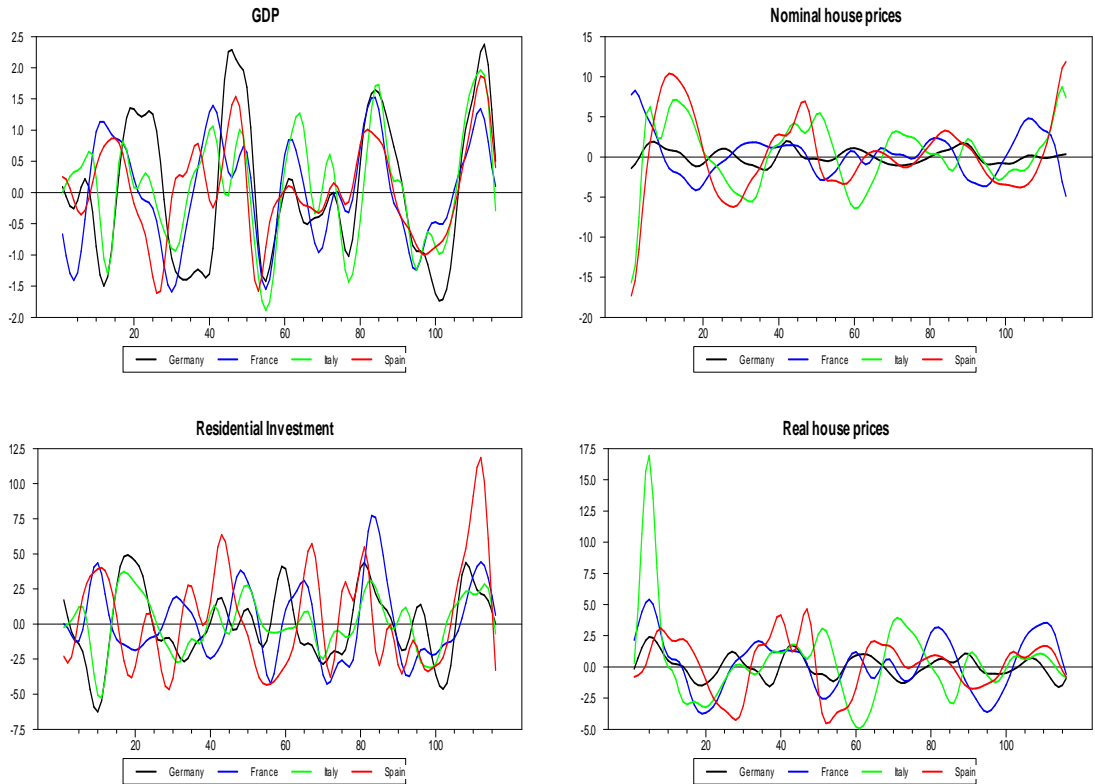
$$BPF(L, F) = \frac{(1-L^2)^d (1-F^2)^d}{(1-L^2)^d (1-F^2)^d + \lambda(1-\alpha L + L^2)^d (1-\alpha F + F^2)^d}$$

where d is an integer parameter, $\alpha = \cos((\omega_{p2} + \omega_{p1})/2) / \cos((\omega_{p2} - \omega_{p1})/2)$, 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 gain of the filter at a pre-specified period equals one-half. Note that larger values of d produce sharper filters, so they provide a better approximation to the ideal filter.

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 of the series⁴. 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)



⁴ Estimates are carried out using programs TRACE (Gómez (1999) and TRAMO and SEATS (Gómez and Maravall (1996)).

3. Results

In this section, we describe the cyclical comovements across the four 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 quantity related construction indicators⁵: 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 and 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 we also consider their dynamic relationships, by analysing the maximum cross-correlation coefficient and maximum 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 cyclical turning points, so they can deal with linear and non-linear relationships between variables, but at the expense of discarding some information.

In addition, we consider a measure of multivariate linear dependence put forward by Peña and Rodriguez (2003) and referred to as “effective dependence” in the remaining. 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 $PR=0$, whereas $PR=1$ 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.

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.

3.1 Correlation analysis

First, we consider aggregate GDP cycles, then housing volumes construction cycles, and, finally housing price cycles. For each variable, Table 1 contains the average of all contemporaneous bivariate correlations among countries, as well as measures of effective dependence.

a) Aggregate activity cycles

Table 1 reports comovement results for GDP and other macro-variables, GDP being 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 (*e.g.* de Bandt, Herrmann and Parigi (2006)), and that synchronization has increased since the mid-nineties (*e.g.* de Haan, Inklaar and Jong-A-Pin (2008)). Our results, 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 between Germany and France) and 0.66 (between Italy and France, as well as France and Spain). We find an effective dependence coefficient of 0.36, which is the highest among the variables considered. The cross-correlation analysis reveals that the bulk of comovement is contemporaneous, with the exception of Spain, which tends to lead the other countries (Germany and Italy by two quarters and France by one 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, partly reflecting the reunification process (Appendices 4 and 5).

b) Construction cycles

Synchronization between *residential investment* cycles is considerably lower than among GDPs, with correlation of 0.29 and effective dependence of 0.21. This suggests that country-specific factors tend to play a stronger role in domestic housing markets. Indeed, with the exceptions of Italian and German cycles, which are strongly correlated (0.71) the remaining pairwise correlation coefficients are generally low leading to low effective dependence. Cross-correlation analysis confirms this point and also shows that the Spanish housing investment cycle slightly leads the French one. (Appendices 4 and 5)

Residential investment, as defined in quarterly national accounts, covers the construction of new buildings as well as the renovating/upgrading of existing buildings. Cyclical developments in these two types of investment may be different, so it is worthwhile to separate them. National Accounts data do 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 France⁶. Nonetheless, the correlation between *housing starts* cycles in France and Spain is much stronger (0.73) than when considering total residential investment, with the French cycle slightly leading the Spanish one. The French *building permits* cycle also slightly leads the Spanish one, both cycles being strongly cross-correlated (0.77). These facts suggest that renovation/upgrade cycles in France and Spain should differ. German building permits in general do not appear to be related to Spanish or French ones.

Cycles in *non-residential construction investment* show a moderate correlation of the French cycle with respect to the other countries (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 seems unrelated to the Italian and Spanish ones.

Table 1: Average of pair-wise contemporaneous correlation coefficients and measures of effective dependence over 1980q1-2008q4 and 1999q1-2008q4

| | Average correlations | | Effective dependence | |
|--|----------------------|-----------------|----------------------|-----------------|
| | 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 | 0.21 | 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 |
| Nominal house prices | 0.09 | 0.17 | 0.28 | 0.35 |
| Real house prices | 0.33 | 0.22 | 0.18 | 0.34 |

Synchronization among *total investment in construction* variables is lower than that observed for household residential investment (pairwise average correlation 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 between Germany and Italy⁷, 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 ones and the lagging nature of the latter. German cycles for that variable seem to be uncorrelated at any lead and lag with the remaining countries, showing, thus, highly idiosyncratic dynamics (Appendices 4 and 5).

⁶ The time series for the number of building permits is too short for Italy and in Germany several government interventions aimed at the abolishment of subsidies for residential investment provoked each time a strong anticipation of permits. This, in turn, affects significantly the correlation and lead-lag relationships to other housing variables and we prefer to reserve the analysis of public interventions in the housing sector for further research. We refer for example to Antipa and Schalck (2009) for such an analysis for France

⁷ 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.

We also find a weak synchronization of *employment in the construction* sector (pairwise average correlation 0.27, effective dependence 0.23), with the 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 more strongly synchronized than investment. Synchronization among *value added in construction* variables is low on average (0.19), ranging 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 only between Spain and Italy (correlation 0.79) and a negative correlation of the French cycle with the Spanish and Italian ones (-0.41 in both cases). 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 of the former with respect to the latter.

As the behaviour of nominal house prices might reflect that of the general price level (see, *e.g.* Tsatsaronis and Zhu (2004)), 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). 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 the sequence of turning points in the cycles 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 allows not only a positive relationship but also a negative one, while a concordance index treats a negative relationship as unrelated. In fact, the concordance index measures the fraction of time two binary variables are in the same regime. 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 the following rule:

$$\begin{aligned} \text{Peak at } t: & \quad \{ y_t > y_{t-k}, y_t > y_{t+k}, k=1, \dots, K \} \\ \text{Trough at } t: & \quad \{ y_t < y_{t-k}, y_t < y_{t+k}, k=1, \dots, K \}, \end{aligned}$$

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.

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 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 (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 $S_i = 1 - S_j$. 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 focus on 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 lead (lag) that maximizes the CCI. In addition, when the concordance is found to be strong between two countries, we carry out a lead-lag analysis that consists in computing the average lead (lag) of turning points in one country by comparison with the other one. Obviously, strongly related countries will share more common turning points. 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 four countries have experienced four complete cycles from peak to peak, if we include the last peak that we provisionally place in 2007q4 or 2008q1 depending on the country⁸. 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). 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). We have carried out a lead-lag analysis on turning points (see Figure 2) and computed average and median distances between turning points. In Figure 2, a positive value between two countries indicates that the first country leads the second one, and conversely. Because of the small number of points (between 5 and 10 points), median values more robust and are thus useful to avoid an overly strong influence of extreme values. It turns out that the German cycle lags Spanish and French ones by around three quarters, while it is more coincident with the Italian one. As in the case of cross correlations, we find that Spanish and French GDP cycles tend to lead those of Italy and Germany.

b) Construction cycles

Regarding *residential investment* cycles, the concordance indexes confirm the results from correlation analysis that synchronization is lower than for GDP cycles. Also in line with previous analysis is the high concordance between France and Spain (0.72) and between Italy and Germany (0.69). The latter is, however, generally poorly synchronized with other countries, possibly due to the intertemporal distortions connected with the German reunification (see also Knetsch, 2009, on this point). Note that concordance measures show that the Italian residential investment cycle lags the other ones, in contrast with the correlation analysis (see Figure 3). Regarding *building permits* and *housing starts* concordance indexes between France and Spain are high (0.75) with a French lead of two quarters. The lead-lag analysis reveals an average lead of one quarter and a median lead of two quarters for French building permits, while the average and median leads are both two quarters for French housing starts. In line with results from 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.

correlation analysis, developments in the number of building permits in Germany do not appear to be related to those in France and Spain.

Figure 2: Lead-lag analysis for GDP growth cycles by country pairs (average and median lead-lag in number of quarters, a positive value indicates that the first country leads the second one and conversely)

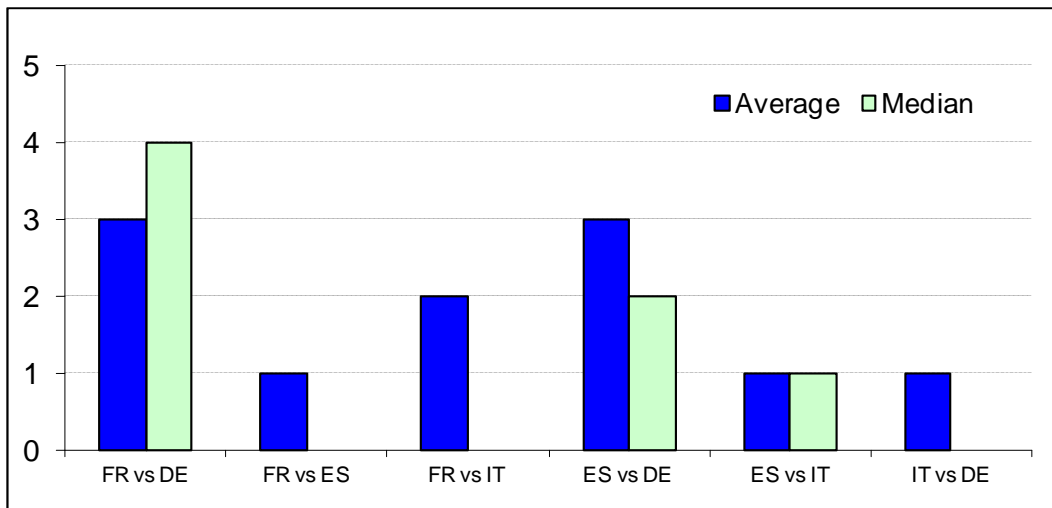
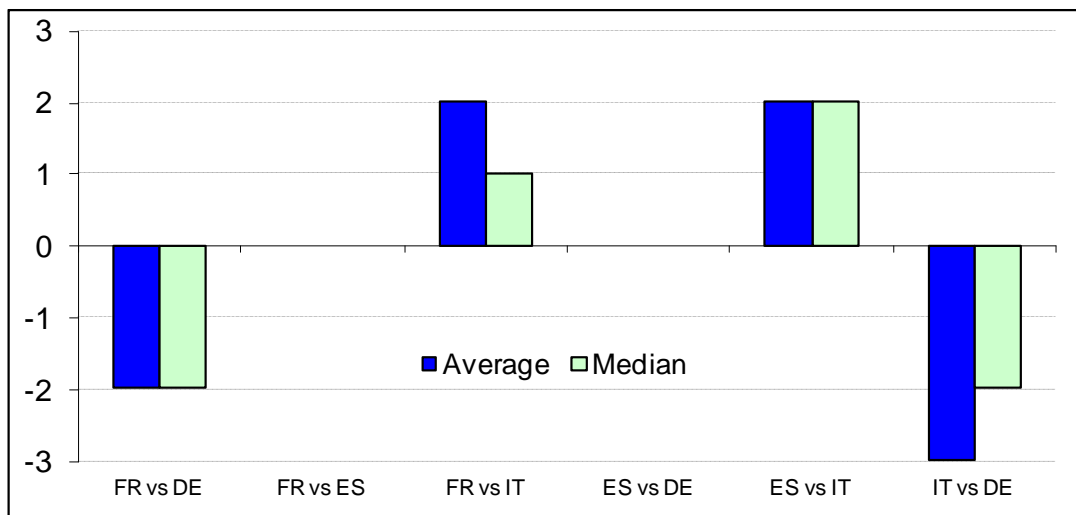


Figure 3: Lead-lag analysis for residential investment cycles by country pairs (average and median lead-lag in number of quarters, a positive value indicates that the first country leads the second one and conversely)



Regarding *non-residential investment in construction*, there is a high degree of concordance between France and the other three countries. Note also that Spain tends to lead Germany and Italy. 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. Relationships between the remaining series for investment in construction are characterized by stronger ties (between France and Spain CI of 0.79). Furthermore, Italy lags France (two quarters) and Spain (four quarters), with a high degree of concordance (0.74 and 0.71, respectively), a finding in line with results from the correlation analysis.

Employment 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 that Spain leads the remaining countries, in line with correlation analysis by around two quarters. Concordance analysis shows a tighter relation between the countries than correlation analysis.

c) House prices cycles

Overall, results for nominal and real house prices reinforce the diagnosis of idiosyncratic behaviour for domestic housing markets, especially in the case of nominal prices. Indeed, we observe that high concordance indexes are not common for nominal prices, with two exceptions: a high concordance value between Spain and Italy (0.78) and a strong relationship between Germany and Spain (CI=0.69), Germany being leading. The rest of CIs are not higher than 0.60. We also find that the Italian cycle seems to be systematically lagging.

Synchronisation is slightly higher in terms of real house prices, reflecting commonalities in consumer price inflation developments. The highest concordance indexes correspond to France and Germany (CCI=0.68) and France and Spain (CCI=0.65), France leading in both cases by one quarter. For the rest of country pairs, the degrees of concordance are very weak, but we observe again that the Italian cycle is systematically lagging.

To sum up the results on cross country comovement, 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. Volume cycles in Germany and Italy share a different cycle

from that between France and Spain. Moreover, Spain tends to lead the other countries. Evidence from housing price cycles confirms the idiosyncratic nature of housing markets.

3.3 Increasing comovements 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 index⁹, defined at each date by

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

where $S_{i,t}^j$ 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 $i=1, \dots, n$, $S_{i,t} = 0$ or $S_{i,t} = 1$). This index is bounded between 0 and 1. Thus, we define SI by

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

where $1\{\cdot\}$ 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)). Housing volume cycles consistently show an increase in synchronization, particularly strong for residential investment and milder for housing starts, which already showed a very high value¹⁰. Results for house prices are mixed, depending on the measure considered. Regarding real house prices, the average correlation reduces from 0.33 to 0.22 during the EMU period, while the effective comovement measure increases from 0.18 to 0.34. However, regarding real house prices, both measures increase. Furthermore, changes in house prices during the EMU period are smaller than 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 too short.

Figure 4: Bivariate synchronization: average pairwise correlation

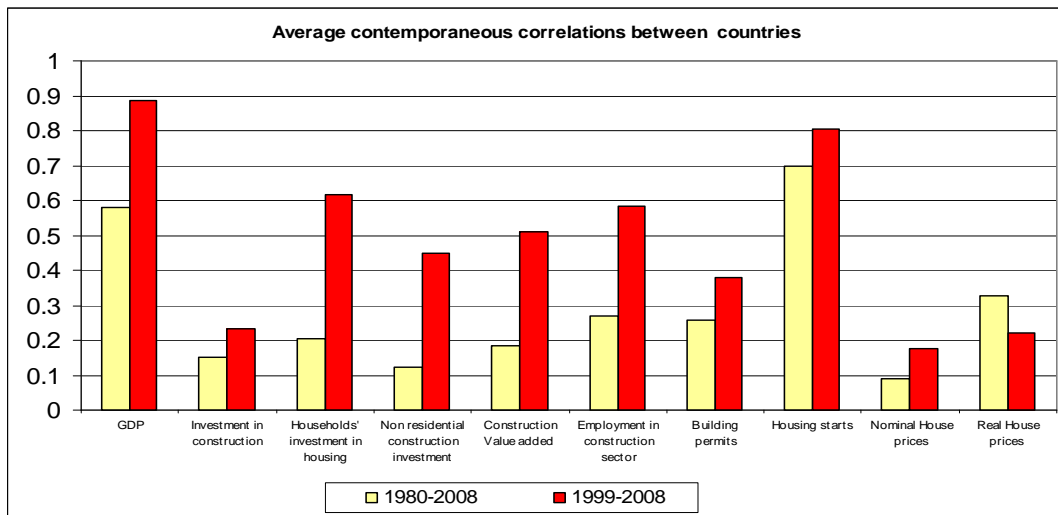


Figure 5: Multivariate synchronization: effective dependence

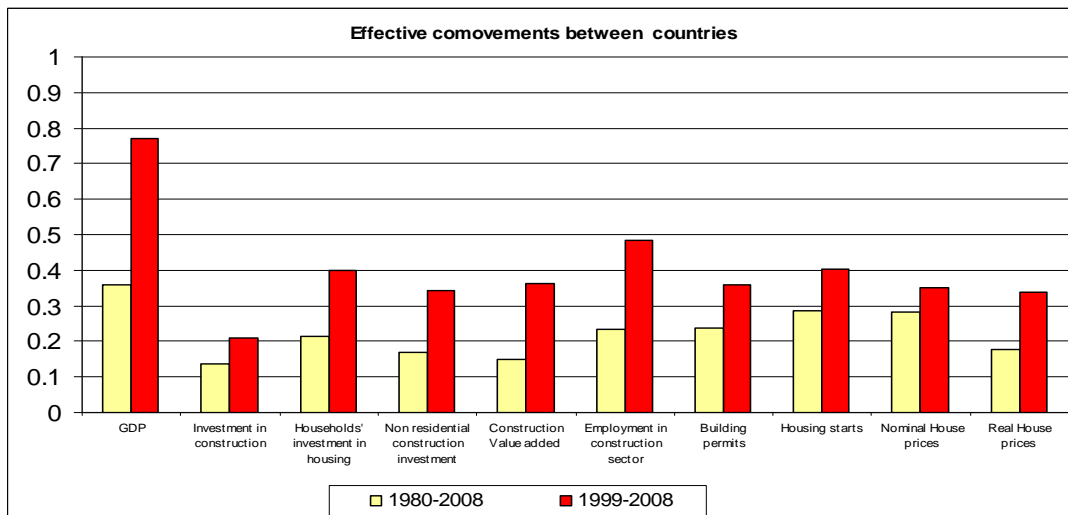
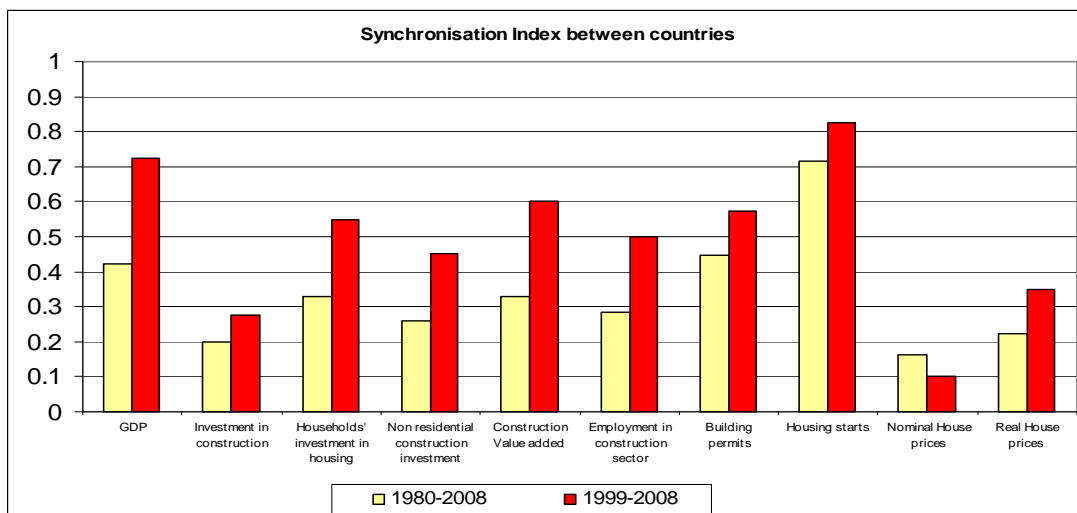


Figure 6: Multivariate synchronisation: diffusion index



4. Conclusions

Recent years have seen an increase 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. We take a fully nonparametric approach both in the calculation of cyclical components and in the dating of turning points.

As a benchmark to which we compare housing cycles, 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, particularly in Germany. Cross country comovements are mostly contemporaneous, but developments in Spain tend to lead those in Germany, Italy and France by one or two 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 and Italy seems to be lagging. 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, probably reflecting the 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.

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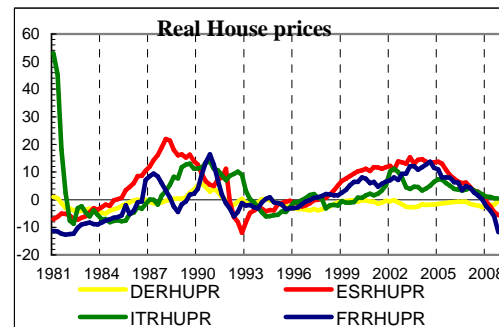
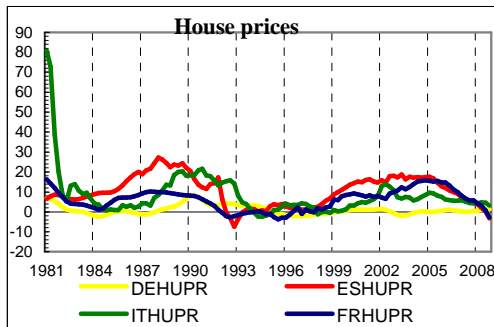
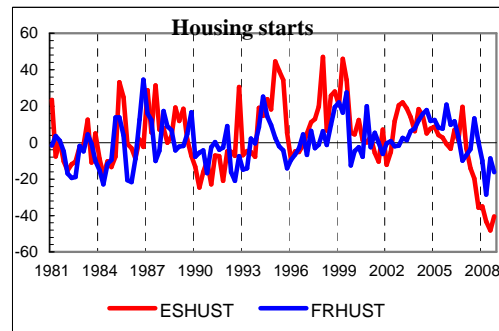
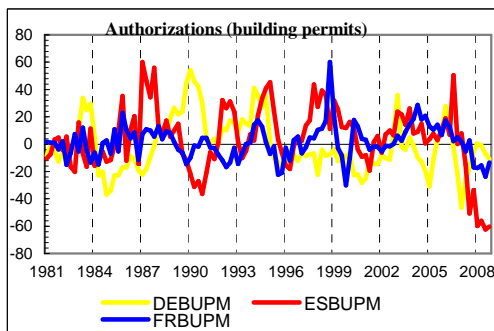
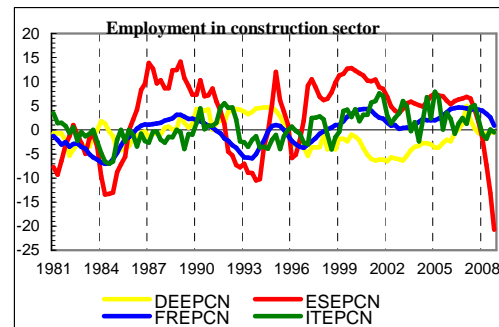
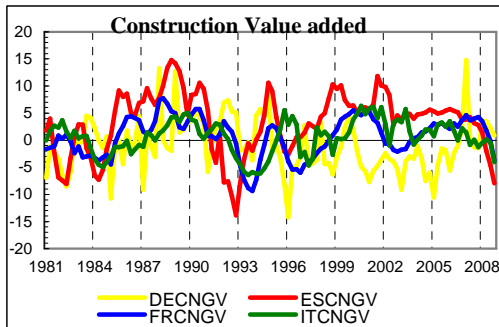
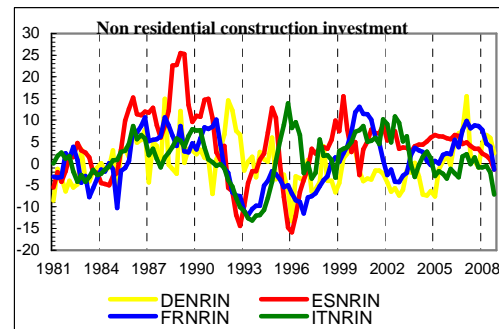
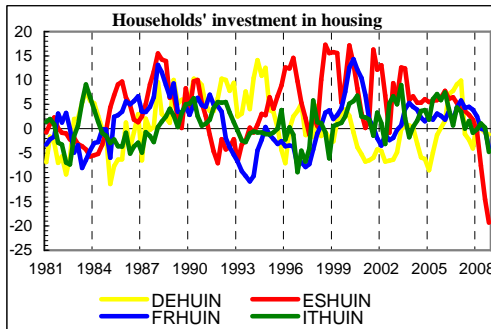
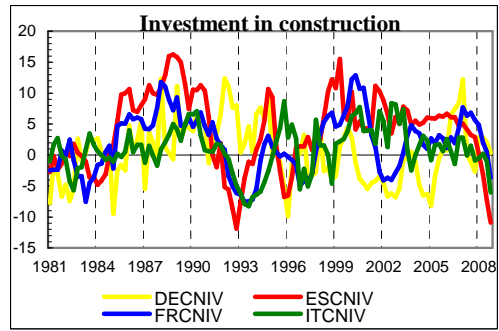
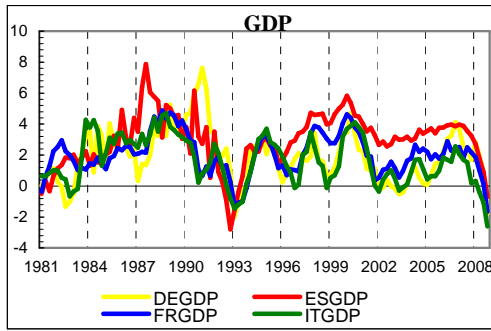
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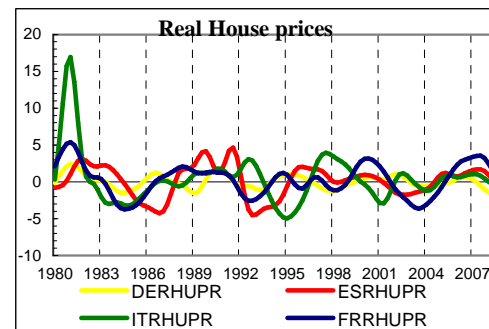
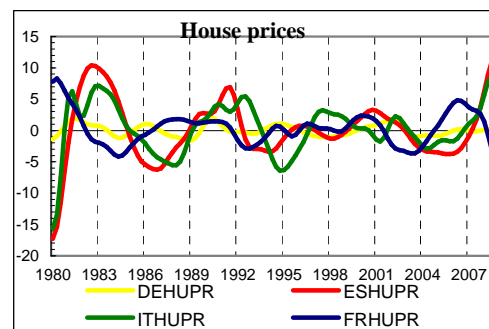
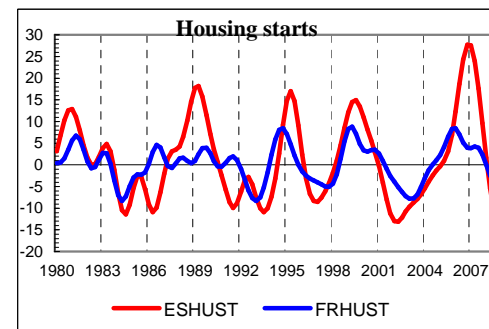
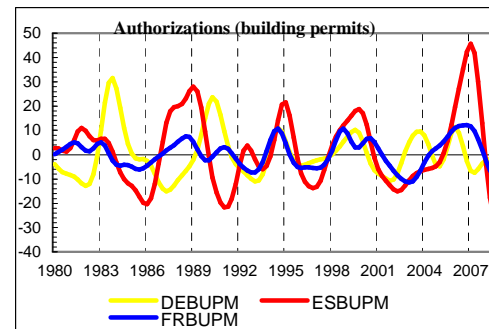
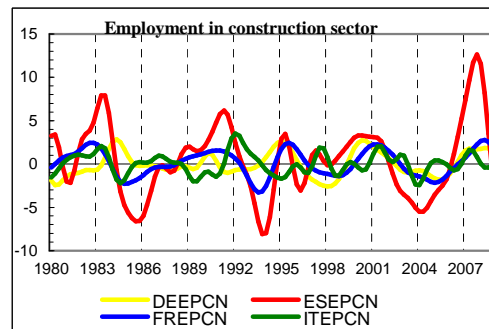
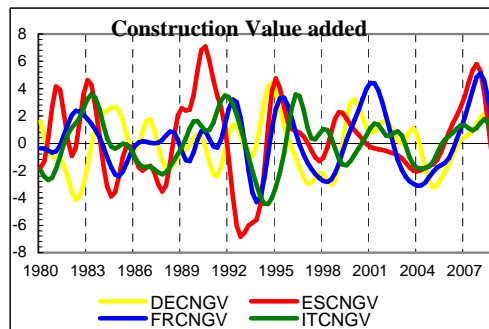
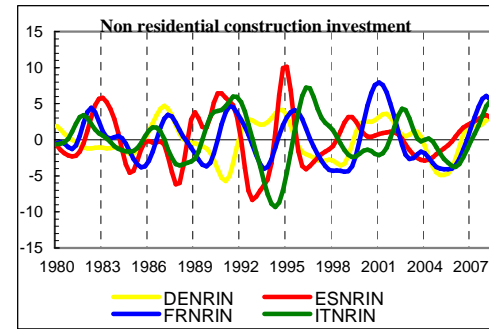
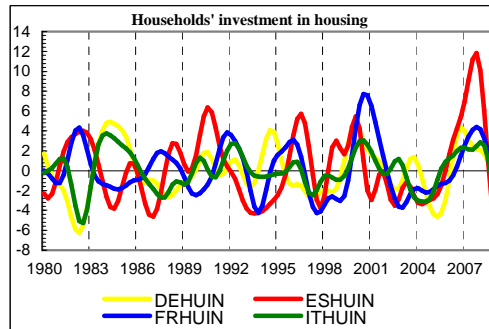
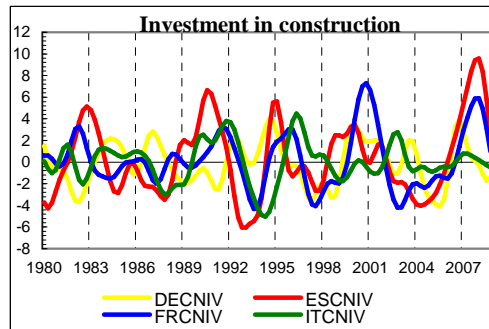
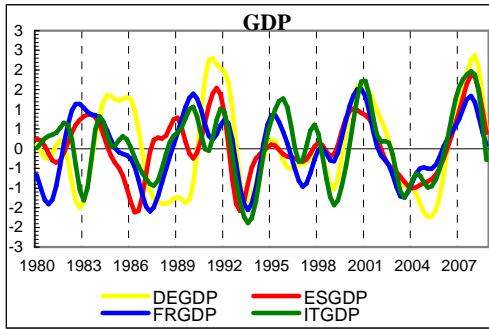
Appendix 1: Description of the 10 variables included in the dataset

| | 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: Construction in 1991: 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 Survey (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'Écologie, de l'Énergie, du Développement 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'Écologie, de l'Énergie, du Développement 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: "e" per square meter. Until 1980:04 BdE elaboration. Since 1987:Q1, Ministry of Housing, likening bases 2000 (until 2005:Q4) and 2005:Q1 (since 2006:Q1) | Comment: Price index of existing dwellings in France, SA, base 100 in 2000 Q4. Back-calculation using annual historical 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 (1980q1 - 2008q4)



Appendix 3: Estimated growth cycles for the 10 variables (1980q1 – 2008q4)



Appendix 4: Cross-correlation (1980q1 - 2008q4)

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 | | | | 1.00 |

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 | | | | 1.00 |

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 | | | | 1.00 |

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 | | | | 1.00 |

Housing starts

Contemporaneous

| | DE | ES | FR | IT |
|----|----|------|------|------|
| DE | | | | |
| ES | | 1.00 | 0.70 | |
| FR | | 0.70 | 1.00 | |
| IT | | | | 1.00 |

Lead /lag 1

| | DE | ES | FR | IT |
|----|----|------|------|------|
| DE | | | | |
| ES | | 0.94 | 0.61 | |
| FR | | 0.73 | 0.92 | |
| IT | | | | 1.00 |

Lead /lag 2

| | DE | ES | FR | IT |
|----|----|------|------|------|
| DE | | | | |
| ES | | 0.79 | 0.49 | |
| FR | | 0.69 | 0.72 | |
| IT | | | | 1.00 |

Lead /lag 4

| | DE | ES | FR | IT |
|----|----|------|------|------|
| DE | | | | |
| ES | | 0.33 | 0.22 | |
| FR | | 0.45 | 0.22 | |
| IT | | | | 1.00 |

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 | |

Appendix 5: Maximal cross-correlation (1980q1 - 2008q4)

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 (1999q1 - 2008q4)

| GDP | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
|--|-------|-------|-------|--------------------|----|-------|-------|--------------------|-------|----|-------|--------------------|-------|-------|----|-------|-------|-------|-------|
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | ES | FR | IT | DE | ES | FR | IT | DE | ES | FR | IT | DE | ES | FR | IT | | | | |
| DE | 1.00 | 0.93 | 0.85 | 0.92 | DE | 0.96 | 0.84 | 0.72 | 0.86 | DE | 0.84 | 0.70 | 0.54 | 0.73 | DE | 0.53 | 0.37 | 0.14 | 0.33 |
| ES | 0.93 | 1.00 | 0.92 | 0.85 | ES | 0.95 | 0.96 | 0.85 | 0.84 | ES | 0.92 | 0.87 | 0.74 | 0.78 | ES | 0.74 | 0.61 | 0.46 | 0.55 |
| FR | 0.85 | 0.92 | 1.00 | 0.85 | FR | 0.91 | 0.92 | 0.95 | 0.89 | FR | 0.89 | 0.85 | 0.83 | 0.85 | FR | 0.74 | 0.62 | 0.48 | 0.60 |
| IT | 0.92 | 0.85 | 0.85 | 1.00 | IT | 0.89 | 0.80 | 0.77 | 0.93 | IT | 0.78 | 0.69 | 0.51 | 0.77 | IT | 0.51 | 0.40 | 0.11 | 0.34 |
| Investment in construction | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.32 | 0.44 | 0.03 | DE | 0.88 | 0.34 | 0.54 | 0.11 | DE | 0.58 | 0.31 | 0.57 | 0.18 | DE | -0.03 | 0.18 | 0.40 | 0.13 |
| ES | 0.32 | 1.00 | 0.69 | 0.06 | ES | 0.30 | 0.96 | 0.70 | 0.09 | ES | 0.26 | 0.87 | 0.69 | 0.12 | ES | 0.22 | 0.64 | 0.62 | 0.16 |
| FR | 0.44 | 0.69 | 1.00 | -0.15 | FR | 0.29 | 0.64 | 0.94 | -0.18 | FR | 0.17 | 0.56 | 0.80 | -0.14 | FR | 0.09 | 0.36 | 0.35 | 0.10 |
| IT | 0.03 | 0.06 | -0.15 | 1.00 | IT | -0.05 | 0.04 | -0.16 | 0.87 | IT | -0.03 | 0.01 | -0.17 | 0.64 | IT | 0.05 | -0.09 | -0.20 | -0.19 |
| Households' investment in housing | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.64 | 0.63 | 0.60 | DE | 0.91 | 0.56 | 0.74 | 0.51 | DE | 0.69 | 0.43 | 0.77 | 0.41 | DE | 0.14 | 0.12 | 0.58 | 0.20 |
| ES | 0.64 | 1.00 | 0.48 | 0.66 | ES | 0.65 | 0.92 | 0.60 | 0.68 | ES | 0.59 | 0.72 | 0.65 | 0.65 | ES | 0.44 | 0.39 | 0.63 | 0.50 |
| FR | 0.63 | 0.48 | 1.00 | 0.71 | FR | 0.46 | 0.33 | 0.94 | 0.62 | FR | 0.29 | 0.17 | 0.78 | 0.49 | FR | 0.05 | -0.05 | 0.30 | 0.24 |
| IT | 0.60 | 0.66 | 0.71 | 1.00 | IT | 0.64 | 0.57 | 0.73 | 0.92 | IT | 0.67 | 0.47 | 0.69 | 0.74 | IT | 0.62 | 0.30 | 0.50 | 0.33 |
| Non residential construction investment | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.51 | 0.83 | 0.42 | DE | 0.95 | 0.39 | 0.83 | 0.54 | DE | 0.82 | 0.27 | 0.77 | 0.63 | DE | 0.48 | -0.02 | 0.49 | 0.69 |
| ES | 0.51 | 1.00 | 0.47 | 0.15 | ES | 0.67 | 0.96 | 0.56 | 0.32 | ES | 0.78 | 0.87 | 0.63 | 0.44 | ES | 0.87 | 0.60 | 0.75 | 0.57 |
| FR | 0.83 | 0.47 | 1.00 | 0.31 | FR | 0.77 | 0.45 | 0.95 | 0.44 | FR | 0.67 | 0.40 | 0.83 | 0.53 | FR | 0.47 | 0.18 | 0.41 | 0.62 |
| IT | 0.42 | 0.15 | 0.31 | 1.00 | IT | 0.28 | -0.01 | 0.16 | 0.95 | IT | 0.13 | -0.20 | -0.01 | 0.80 | IT | -0.18 | -0.61 | -0.33 | 0.32 |
| Construction Value added | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.31 | 0.62 | 0.30 | DE | 0.92 | 0.15 | 0.56 | 0.25 | DE | 0.72 | -0.01 | 0.48 | 0.18 | DE | 0.33 | -0.32 | 0.28 | 0.03 |
| ES | 0.31 | 1.00 | 0.62 | 0.48 | ES | 0.50 | 0.95 | 0.72 | 0.53 | ES | 0.62 | 0.82 | 0.75 | 0.55 | ES | 0.73 | 0.55 | 0.74 | 0.54 |
| FR | 0.62 | 0.62 | 1.00 | 0.72 | FR | 0.64 | 0.51 | 0.96 | 0.77 | FR | 0.64 | 0.37 | 0.86 | 0.76 | FR | 0.65 | 0.09 | 0.55 | 0.61 |
| IT | 0.30 | 0.48 | 0.72 | 1.00 | IT | 0.34 | 0.44 | 0.62 | 0.94 | IT | 0.41 | 0.41 | 0.51 | 0.80 | IT | 0.55 | 0.32 | 0.25 | 0.41 |
| Employment in construction sector | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.76 | 0.87 | 0.29 | DE | 0.96 | 0.68 | 0.92 | 0.35 | DE | 0.84 | 0.58 | 0.92 | 0.43 | DE | 0.52 | 0.26 | 0.76 | 0.49 |
| ES | 0.76 | 1.00 | 0.72 | 0.43 | ES | 0.82 | 0.95 | 0.86 | 0.39 | ES | 0.81 | 0.83 | 0.91 | 0.33 | ES | 0.74 | 0.55 | 0.89 | 0.27 |
| FR | 0.87 | 0.72 | 1.00 | 0.45 | FR | 0.76 | 0.58 | 0.97 | 0.44 | FR | 0.62 | 0.43 | 0.89 | 0.44 | FR | 0.30 | 0.07 | 0.58 | 0.34 |
| IT | 0.29 | 0.43 | 0.45 | 1.00 | IT | 0.22 | 0.44 | 0.46 | 0.82 | IT | 0.19 | 0.36 | 0.46 | 0.40 | IT | 0.18 | 0.04 | 0.39 | -0.26 |
| Building permits | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.19 | 0.10 | | DE | 0.90 | 0.32 | 0.26 | | DE | 0.62 | 0.43 | 0.43 | | DE | -0.12 | 0.52 | 0.67 | |
| ES | 0.19 | 1.00 | 0.85 | | ES | 0.04 | 0.95 | 0.79 | | ES | -0.13 | 0.78 | 0.66 | | ES | -0.41 | 0.26 | 0.26 | |
| FR | 0.10 | 0.85 | 1.00 | | FR | -0.08 | 0.83 | 0.96 | | FR | -0.24 | 0.76 | 0.84 | | FR | -0.46 | 0.49 | 0.47 | |
| IT | | | | | IT | | | | | IT | | | | | IT | | | | |
| Housing starts | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | | | | | DE | | | | | DE | | | | | DE | | | | |
| ES | | 1.00 | 0.80 | | ES | | 0.96 | 0.75 | | ES | | 0.83 | 0.67 | | ES | | 0.42 | 0.39 | |
| FR | | 0.80 | 1.00 | | FR | | 0.81 | 0.96 | | FR | | 0.77 | 0.85 | | FR | | 0.58 | 0.52 | |
| IT | | | | | IT | | | | | IT | | | | | IT | | | | |
| House prices | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | 0.47 | -0.05 | 0.26 | DE | 0.95 | 0.42 | -0.21 | 0.29 | DE | 0.81 | 0.35 | -0.36 | 0.28 | DE | 0.40 | 0.20 | -0.62 | 0.19 |
| ES | 0.47 | 1.00 | -0.26 | 0.86 | ES | 0.53 | 0.98 | -0.39 | 0.78 | ES | 0.60 | 0.91 | -0.51 | 0.67 | ES | 0.63 | 0.58 | -0.72 | 0.31 |
| FR | -0.05 | -0.26 | 1.00 | -0.23 | FR | 0.13 | 0.00 | 0.95 | 0.02 | FR | 0.29 | 0.25 | 0.82 | 0.26 | FR | 0.53 | 0.58 | 0.48 | 0.58 |
| IT | 0.26 | 0.86 | -0.23 | 1.00 | IT | 0.22 | 0.87 | -0.34 | 0.96 | IT | 0.17 | 0.84 | -0.41 | 0.85 | IT | 0.04 | 0.66 | -0.52 | 0.48 |
| Real House prices | | | | Lead /lag 1 | | | | Lead /lag 2 | | | | Lead /lag 4 | | | | | | | |
| Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | Contemporaneous | | | | | | | |
| DE | 1.00 | -0.06 | 0.19 | 0.02 | DE | 0.93 | -0.07 | 0.18 | 0.10 | DE | 0.76 | -0.10 | 0.14 | 0.11 | DE | 0.21 | -0.31 | -0.09 | -0.04 |
| ES | -0.06 | 1.00 | 0.85 | 0.24 | ES | -0.08 | 0.98 | 0.92 | 0.15 | ES | -0.07 | 0.84 | 0.93 | 0.06 | ES | 0.04 | 0.53 | 0.84 | -0.03 |
| FR | 0.19 | 0.85 | 1.00 | 0.09 | FR | 0.17 | 0.72 | 0.97 | 0.00 | FR | 0.14 | 0.56 | 0.88 | -0.08 | FR | 0.08 | 0.19 | 0.61 | -0.18 |
| IT | 0.02 | 0.24 | 0.09 | 1.00 | IT | -0.11 | 0.31 | 0.19 | 0.91 | IT | -0.25 | 0.37 | 0.28 | 0.65 | IT | -0.44 | 0.44 | 0.39 | -0.03 |

Appendix 7: Maximal cross-correlation (1999q1-2008q4)

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 |

Maxima correlation located in:

| | 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. |

Country row leads/lags country column

| | 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 |

Maxima correlation located in:

| | 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. |

Country row leads/lags country column

| | 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 | 0.78 | 0.57 |
| FR | 0.83 | 0.47 | 1.00 | 0.62 |
| IT | 0.42 | 0.15 | 0.31 | 1.00 |

Maxima correlation located in:

| | 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. |

Country row leads/lags country column

| | 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 |

Maxima correlation located in:

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

Country row leads/lags country column

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

Employment in construction sector

| | DE | ES | FR | IT |
|----|------|------|------|------|
| DE | 1.00 | 0.76 | 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 | | | | 1.00 |

Maxima correlation located in:

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

Country row leads/lags country column

| | 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 | | | | 1.00 |

Maxima correlation located in:

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

Country row leads/lags country column

| | 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 |

Maxima correlation located in:

| | 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. |

Country row leads/lags country column

| | 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 |

Maxima correlation located in:

| | 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. |

Country row leads/lags country column

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

Appendix 8: Concordance indexes (1980q1 - 2008q4)

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 | 0.84 |
| 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 |
|--|----|----|----|----|
|--|----|----|----|----|

Appendix 9: Maximal cross-concordance and leading degree (1980q1 - 2008q4)

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 | 0.60 |
| ES | 0.60 | 1.00 | 0.72 | 0.72 |
| FR | 0.60 | 0.75 | 1.00 | 0.60 |
| 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 | 0.48 | 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 | -- |

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