International diversification benefits -a view on time-varying European market integration

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Abstract

National real estate markets are usually considered to be segmented one from the other. International diversification benefits in real estate markets have been shown to be larger than those in equity or bond markets. New developments in Europe (single market, monetary union, post-crisis coordination of macroprudential policies) are expected to increase integration and reduce these benefits. We study the time-varying degree of integration of European real estate markets over 1971-2018 by estimating the explanatory power of a multi-factor linear model. We find that the integration was relatively stable over time, with a temporary rise during the 2008 financial crisis. We also note that the integration dynamics within Europe has not become stronger than with non-European countries. We find that countries are individually highly integrated via the global factors excepted during short-lived events. The data do not detect stable regional clusters. The international diversification of real estate investments still matters.

1 Introduction

The integration of international financial markets has increased over time but real estate assets have long been considered as being segmented, both with respect to equity or bond markets, and across countries. For a real estate investor, geographic diversification has been shown to be profitable (see for empirical examples Eichholtz (1996), Lee (2005) or de Wit (2010)). As noted in the conclusion of de Wit (2010), "investing in assets across regions will result in the highest diversification benefits".

This benefit has however been questioned recently. First, some international studies (Case et al. (2000), Cotter et al. (2015), Joyeux and Milunovich (2015)) have shown a recent rise

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in the integration of national housing markets, especially during the crises episodes. Second, the introduction of the euro and the resulting common monetary policy, together with the growing coordination of macroprudential policies in the wake of the 2008 crisis are candidate for supporting the integration of the housing markets. Whether this is a rise, permanent or temporary, and whether geographic diversification still matters remain unsettled questions that we investigate in this paper.

This question is also motivated by the growing importance of real estate investments in the world. According to a recent MSCI report, the size of the professionally managed global real estate investment market grew by 10% in 2017 and its size reached USD 8.5 trillion, a large figure compared to sovereign wealth fund assets (USD 8 trillion) and hedge funds assets (around USD 3.5 trillion). Although not specific to Europe, the growing financialization of the real estate market is certainly another potential source of (ongoing) market integration.

We here study the time-varying integration of the European real estate markets over the period 1971-2018, based on national return series, as collected and harmonized by the Bank for International Settlements (BIS). We estimate the time-varying integration via the explanatory power of a multi-factor model (following the methodology of Pukthuanthong and Roll (2009)), where the factors are non-observable. We find that European real estate markets are now more integrated than before but we also see that this higher integration is quasi exclusively due to a temporary shift associated to the 2008 crisis. Benefits of geographic diversification still matter for European markets. Looking at national specific integration, we find that the real estate markets have like two regimes, one with large and stable integration with European markets and a second with abrupt and short disconnections. Idiosyncratic factors do still influence the national housing markets and justify the preference for a well diversified real estate portfolio.

This paper is organized as follows: we first review the literature on the integration measures and the empirical results regarding the integration of the European real estate market. We then explain our estimation strategy. The fourth section presents our data and the fifth one the results. We then propose some extensions by comparing the integration within Europe and the integration with non-European countries, and consider a regional clustering approach. Finally, the last section concludes.

2 Review of literature

2.1 Measures of Integration

We cover in this subsection some of the perspectives behind the concept of integration. We first discuss convergence versus synchronization, then look at the different usual proxies (prices, quantity, regulations) and finally present static versus dynamics measures of integration.

2.1.1 Convergence versus synchronization

We investigate the benefits of diversification by looking at the integration of the European housing markets over time. There is however no unique consensual definition of integration. All depends on the perspective and on the final question that is raised. There are basically two perspectives: one on levels and the other on dynamics. The first perspective sees integration as a convergence process where real estate markets start from different initial conditions (say different price levels). The analysis would then assess the existence and speed of a convergence process (see an illustration McAllister (2001) where the integration is estimated through beta convergence or Gallo et al. (2013) where it is estimated in a cointegration framework). The second perspective would rather consider integration as a synchronization dynamic process, where the focus is on exposure to common factors, on co-movements and correlations. Although convergence and synchronization might go hand in hand, this is not necessarily the case. Indeed, a recent study (Jeffrey et al. (2018)) has shown at the Euro area level that the European real economic activity has not converged even though fluctuations are increasingly synchronized. There is a priori no reason to consider that this divide would be different for real estate markets.

Since we have no hedonic price series (correcting for quality levels across countries) allowing to assess the genuine convergence of markets, we will look at integration in terms of synchronicity. This is also the most natural approach as we take the perspective of an investor concerned by the diversification benefits of investing in different European countries.

2.1.2 Price, quantities or regulations

As detailed in Billio et al. (2017), we can assess integration by looking at price measures (returns, rents or yields), but other objects of studies could also be considered. As a first alternative, we can use a quantity indicator that would refer to stocks or flows of real estate. Full integration requires internationally diversified portfolios. For instance, one could measure integration by the share of real estate held by domestic with respect to foreign residents. As the stock of real estate held by foreign residents increases, the impact of domestic idiosyncratic shocks would decrease. In terms of flows, one could analyse the share of real estate transactions carried out by residents or non-residents. A third approach of integration could also be to studying the harmonization of regulations. Sharing the same regulation can facilitate the integration of European markets even though it may not be a sufficient condition for integration. To this respect, integration in real estate would appear limited as property rights have so far not been subject to a specific EU directive. As we are considering the integration of real estate market from a financial diversification view, we will adopt a return perspective.

2.1.3 Dynamic versus static

We consider the evolution of the integration, and therefore rely on dynamic measures, as opposed to static ones. Different tools can be used for estimating the time-varying integration, such as multivariate volatility models (CCC, DCC, BEKK-GARCH), or time-varying beta models (see Billio et al. (2017) for a recent survey). Nevertheless, most of these measures are subject to the critics of Pukthuanthong and Roll (2009) which state that: "Correlations can be small even when two countries are perfectly integrated. This occurs whenever there are multiple global sources of return volatility and countries do not share the same sensitivities to all of them". They therefore suggest to use a multi-factor model where the integration of the real estate return series is measured by the time-varying explanatory power of the global factors. If that proportion is small, the country is dominated by local or idiosyncratic influences, but if a group of countries is highly sensible to the same global influence, there will be a high degree of integration.

Two advantages of this approach are first that the analysis does not require to choose observable global factors - these are latent factors, second that we obtain a measure of integration that is comparable over time as the change in R^2 indicates the change in the market integration. This quite novel approach has been implemented by Pukthuanthong and Roll (2009) for the equity market, by Christoffersen et al. (2019) for commodity markets and by Cotter et al. (2015) who relate their dynamic measure to specific macro and financial variables.

2.2 Integration of European real estate markets

We are not the first to study the integration of European real estate markets. Druica et al. (2015) proxy measures of returns and rental yields in residential real estate in Europe and explore the correlation of these variables with factors such as GDP, population and inflation. They find that the same structural factors drive real estate returns. Bond et al. (2003) have shown that commercial real estates are fragmented. They use a multi-factor international asset pricing model and show evidence of a strong global risk factor in almost all real estate sectors. The diversification benefits of real estate are thus confirmed, but it appears to be more relevant in Asia-Pacific markets than in European markets. Still, these papers focus on static statistics, contrary to our approach based one evolution of the housing real estate market integration.

Other studies taking this time-varying integration on board look at the sigma-convergence, which summarizes the evolution of a distribution over time. There is integration according to sigma-convergence when the dispersion in the distribution falls over time.McAllister (2001) used sigma convergence on RE rental prices in the office market, and show no sign of sigma convergence when applied to the office rents of 25 cities in Europe between 1984 and 1999. However with a larger time scope (1982-2009) Srivatsa and Lee (2010) found sign of significant sigma convergence, but their sample is smaller with only 7 European office markets.

Some papers have taken country specific focus and have considered the time-varying integration with other European countries. Lee (2009) show that the returns of the UK securitised real estate market was more influenced by movements in the other countries in Europe market rather than the USA between 1998 and 2004, but since 2004, the returns in the UK real estate have started to diverge from those of most countries in Europe. Lee (2010) replicated his method to the Spanish securitised real estate market, and show that there is sign of convergence with some European countries, but not all of them, suggesting that diversification of portfolios within Europe is still viable but the choice of the country is crucial.

To sum up, no paper has analyzed the evolution of the integration of the European real estate markets. The residential market has been analyzed from a static perspective, and the result of the study show no sign of integration. Then, the office market show in the most recent period sign of decreasing dispersion in the price movement, suggesting convergence but not necessarily integration. Finally, studies that have tested the integration of national real estate markets with respect to the rest of Europe tend to show little sign of integration.

3 Methodology

This section describes the methodology employed to measure the time-varying degree of integration of the European real estate markets.

3.1 Benchmark model

As standard correlation coefficients are not designed for disentangling low integration from large heterogeneity[1], we opt for an alternative approach where integration is measured by the explanatory power of a multi-factor linear model (following Pukthuanthong and Roll (2009) who implement this methodology for assessing the rising integration of equity markets). The factors used in this methodology are designed to capture the key driving source of variation in the housing returns, and are obtained by computing the principal components from the spectral decomposition of the correlation matrix of the annual percentage variations of our housing price series. More formally, the factors are computed as follows:

$$F_{k,t} = e_{k,1} r_{1,t} + \dots\ e_{k,i} r_{i,t} + \dots\ e_{k,N} r_{N,t} \qquad (1)$$
$$i = 1, \dots N \qquad k = 1, \dots K \qquad t = 1, \dots T$$

where N is the number of housing price series (i.e. the number of countries), $K < N$ is the number of factors, T is the size of the time series, $F_{k,t}$ is the factor (i.e. principal component) k at time t, $e_{k,i}$ is the i-th element of the N-dimensional eigenvector associated to the principal component k (and to the eigenvalue λ_k), $r_{i,t}$ is the annual percentage variation of the real estate quarterly price series of country i in year t.

[1]Well integrated countries could be lowly correlated if they have not the same sensitivities to global sources of variations.

The Equation 1 shows that the factors are built as linear combinations (or weighted "averages" where $\sum_{i=1}^{N} e_{k,i}^2 = 1 \; \forall k$) of the housing returns. These factors are used as proxies for common sources of variation and are therefore included as explanatory variables in the N multi-factor regressions implemented separately for each real estate national market:

$$\begin{aligned} r_{i,t} &= \beta_{i,1} F_{-i,1,t} + ... \; \beta_{i,k} F_{-i,k,t} + ... \; \beta_{i,K} F_{-i,K,t} \\ -i &= 1, 2 \; ..., i-1, i+1, \; ..., N \end{aligned} \tag{2}$$

where $\beta_{i,k}$ is the country i exposure (or factor loading) to the global factor k, where the subscript $-i$ in $F_{-i,k,t}$ explicitly shows that the global factors in the country-i specific regression are computed without consideration of the real estate returns of country i. If country i real estate returns were not excluded from the computation of the global factors specific to regression i, the explanatory power of the country i regression would artificially be upward biased, with a magnitude depending on the weight of country i returns in the set of the K global factors considered in the regressions. We thus first compute for the country i regression a set of K different factors based on their respective $N-1$ return series and then regress the country i return on this set of K factors, and finally repeat this procedure for the N countries of the sample.

The (adjusted) R^2 obtained from the above regressions are then averaged and give the key outcome for assessing the degree of integration. However, the averaged R^2 is a single figure summarizing the degree of integration of the N real estate markets over the full sample. Our objective was to make it dynamic (time-varying) in view to address our research question of the evolution of integration of the real estate markets. We thus follow Billio et al. (2017) and estimate the cross-country averaged R^2 using a rolling window of 6 years. As detailed in the data section, the time coverage of our data goes from 1971q1 to 2017q4. We will thus ultimately get a set of 160 cross-country averaged R^2 showing the evolution of the explanatory power of global factors, in other words the degree of integration, over time.

3.2 Implementation "details"

As often, devil is in the details in such studies. Our analysis requires to make a set of arbitrary assumptions about the object of the spectral decomposition (correlation or covariance matrix), the handling of potential non-stationarity and seasonality of the data, the consideration of a potential time-delayed integration, the size of the rolling window, the number of global factors. We now discuss carefully these important technical points that can at the end make a big difference.

First, the spectral decomposition of a matrix allows to compute/isolate its eigenvectors and associated eigenvalues. We can either operate the decomposition on the covariance matrix or of the correlation matrix of the real estate returns. Using the covariance matrix consists in allowing different weights to the series, whose magnitude is commensurate to their respective variances. Since there is no reason to expect a larger influence on global factors of highly volatile country - actually we would expect the contrary - we work on correlation matrix (like Billio et al. (2017)). Using the correlation matrix is actually equivalent to working with the covariance matrix of the standardized returns.

Second, the spectral decomposition requires the series to be stationary. Given the non-stationarity resulting from standard non-stationary tests, we work with returns instead of prices as is usual in similar studies. We also notice some country specific seasonality in the data (resulting from tax, weather or job market specificities, among others). We thus work with annual percentage variations our quarterly price series . An alternative might be to rely on deseasonalization tools (such as the X11 filter), but this would be at the cost of a loss of transparency . We also report in the robustness section a comparison with quarterly variations (instead of annual ones).

Third, the global factors are constructed on the basis of the correlation matrix, which only reflects contemporaneous correlations between real estate markets. However, real estate markets are characterized by some rigidities that preclude instantaneous (and full) reflections of the global shocks. Limiting our measure of integration to the sole contemporaneous correlation is too restrictive. We thus consider a model allowing some delay in the shock propagation. We add lagged factors in our benchmark model. Formally,

$$\begin{aligned} r_{i,t} =&\beta_{i,1}F_{-i,1,t} + ...\ \beta_{i,k}F_{-i,k,t} + ...\ \beta_{i,K}F_{-i,K,t}+ \\ &\beta'_{i,1}F_{-i,1,t-1} + ...\ \beta'_{i,k}F_{-i,k,t-1} + ...\ \beta'_{i,K}F_{-i,K,t-1} \end{aligned} \quad (3)$$

where the additional K factors $F_{-i,k,\mathbf{t-1}}$ are lagged factors accounting for potential quarterly delay. We will also explore the sensitivity of our results by comparing different variants of our model (no lag, two quarter lags, three quarter lags).[2]

Fourth, we estimate the cross-country averaged R^2 using a rolling window of 6 years. The longer the rolling window, the longer the sample, the more precise the estimate. The shorter the window, the more reflective it is of the current degree of integration. Given this trade-off, we will also compare our results by varying the length of the rolling window (6, 8 and 10 years respectively). This will also help in documenting the degree of persistence of the 2008 financial crisis in the data.

Finally, the number of factors, K, to be included as explanatory variables is determined by stating that the cumulative proportion of total variance, $(\sum_{k=1}^{K}\lambda_j)/(\sum_{k=1}^{N}\lambda_j)$, (where λ_k stands for the kth largest eigenvalue resulting from the spectral decomposition of the correlation matrix) explained by the K factors must reach the threshold of 80%. We will also explore the sensitivity of this assumption (3, 4 and 5 factors respectively).

[2]Alternatively, Pukthuanthong and Roll (2009) augment the covariance matrix by including one-quarter-lagged returns.

4 Data

4.1 Data Sources

The BIS publishes a so-called Long series data set on residential property prices, which focuses on 18 advanced economies with historical data that go as far back as 1971 on a quarterly basis (Scatigna et al. (2014)). The selected series cover all types of dwelling (flats and houses, new and existing). According to the BIS, this indicator "satisfies some minimum comparability criteria across countries" "without, however, fully eliminating all discrepancies" (Scatigna et al. (2014)). [3]

In terms of geographic coverage, the dataset covers 13 European countries including 11 EU ones (Belgium, Finland, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, United-Kingdom (still in the EU at the time of writing) and 2 non-EU countries like Norway and Switzerland).[4] It also covers 5 non European countries, namely Australia, Canada, Japan, New Zealand and the United States that we use as comparison group in Section 6. The time coverage goes from 1971q1 to 2017q4, i.e. over 188 quarters.

The BIS property price series are not expressed in real terms. The series are therefore deflated with the Consumer Price Indices from the World Bank dataset. [5] Figures 1 and 2 illustrate the evolution of our 13 property price indices in real terms and in annual variations respectively.

INSERT FIGURES 1 AND 2 HERE

We see from these figures that inflation has not affected all countries homogeneously. Given the non-stationarity of price series, the analysis will be carried out on the annual returns of the quarterly price series. We see first that the size of variations was globally larger in the seventies and eighties, second that the variations seem only marginally synchronized, excepted for negative variations clustered around 1981, 1992, 2008 and 2012. From this visual inspection, we expect the degree of integration to be relatively moderate, and expect some factors to capture these relatively well synchronized negative variations. Whether integration rises or stagnates over the window is not straightforward from the sole graphs.

4.2 Descriptive Statistics

We report in Table 1 the descriptive statistics of the annual returns over the window 1972 to 2017. Real annual returns exceed 1% in all countries, even exceeding 3% in Finland,

[3] There is to our knowledge no satisfying quality-controlled hedonic price series. With such data, the synchronization perspective (dynamics) could be completed with a convergence approach (level).

[4] Inversely 17 EU countries are therefore missing, namely Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

[5] CPI as normalized 1995=100 (id:FP.CPI.TOTL).

Norway, Sweden, Netherlands and Italy, which suggests some regional influence might be at play. The size of annual variations is quite large, with standard deviations larger than 7%.

INSERT TABLE 1 HERE

4.3 Correlation Analysis

Correlations of housing returns give a first, static, view on the degree of integration of the European property markets. We report in Figures 3a the average correlations of European housing markets with their respective 12 ($N-1$) counterparts and compare it within the same figure with the average correlations of European housing markets with the 5 non-European countries available in our dataset (AU, CA, JP, NZ, US). We see that average correlations of European housing markets are not much larger within Europe than with the 5 non European countries. Actually, correlation is even larger with non European countries for Belgium, Spain, France and Ireland.

INSERT FIGURE 3 HERE

Average correlations are just aggregations of bilateral correlation measures. To investigate further the significance of pairwise correlations we report in Figure 3b the proportion of significant pairwise correlations (within Europe and with non European countries, respectively). It turns out that correlations are not more significant within Europe than with non European countries. Again, this is a static measure and our point is precisely to see if this has changed over last years or decades. In addition, a low correlation might reflect a low integration of European housing markets but might as well reflect different sensitivities to the global factors. We thus now go to our multi-factor approach.

5 Results

We first present the profile of the global factors, the weight of the respective real estate markets and the time-varying contribution of the factors to the total variance of our data. We then look at the time-varying explanatory power of the global factors in housing return regressions. We also discuss the sensitivity of the results to parameters' changes (number of factors and lags, size of the rolling window). We finally look into our aggregate measure and go at national level by looking at country specific evolution of the adjusted R^2, in view to better assess the representativeness of the aggregate R^2 measure.

5.1 Global factors

The contributions of the global factors in explaining the total variance of housing returns is summarized in Figure 4a which reports the cumulative ordered eigenvalues, as derived from the correlation matrix of the 13 series and averaged over the 160 rolling windows. We see that the main factor explains more than 40% of the total variance, the main 3 factors more than 80% and 4 factors 90%.

INSERT FIGURE 4 HERE

While Figure 4a reports the average contribution of the factors over time (average eigenvalue over the 160 rolling windows), Figure 4b shows the evolution of the respective factors' contributions over time. We see that their contribution is relatively stable with a big shift around 2008 where the contribution of the first factor rises substantially, which is consistent with the general finding of rising correlations on the financial markets during the crisis.

The apparently low degree of integration resulting from visualization of the graphs[6] is corroborated by the Kaiser, Meyer, Olkin (KMO) Measure of Sampling Adequacy, which measures the proportion of variance among variables that might be attributed to common variance. With a measure of sampling adequacy of 0.65 for the full sample, the degree of integration is considered as low (which confirms the relevance of international diversification on the full sample).

We finally look at the eigenvectors in view to identify the contributions of the housing returns to the construction of the global factors. We see from Figure 5 that the first factor is close to the average of the respective annual returns, as all elements of the first eigenvector have a same sign. Quite interestingly, we notice for the second factor a regional logic with a negative sign for most northern countries (NO, SE, DK, FI, NL, BE) and a positive one for the others. The interpretation of the third factor is likely capturing a UK specificity (large and positive value for UK). This is consistent with Lee (2009) who finds that UK real estate markets have started to diverge from European markets as from 2004.

INSERT FIGURE 5 HERE

5.2 Explanatory power of linear multi-factor models

These factors are now injected as explanatory variables in the model set out in Equation 3. The benchmark model thus includes 3 factors ($k = 3$), one set of 3 lagged factors and is based on rolling windows of 6 years (24 quarters). This benchmark model is thus estimated 161 times . We report in Figure 6 the evolution of the explanatory power of this model, i.e. the adjusted R^2, over these 161 quarters (1977-2017). This metrics, that we used as proxy for the degree of integration, is characterized by 3 periods. First, a quite substantial fall of R^2 around 1981, at the time of the global monetary tightening, with country dynamics very heterogeneous. Second a period of stable but declining integration. Finally, a large increase of R^2 at the time of the 2007-2008 financial crisis, capturing the simultaneous slowdown and,

[6]The relative eigenvalue of the first principal component at 40% is quite low compared to what is found for equity markets where it is closer to 60% (Pukthuanthong and Roll (2009))

for some markets, collapse of housing markets, with a subsequent normalization coming back close to the pre-crisis levels. This first result does not support the view of a rising integration, but rather suggests a temporary acuter integration only related to the crisis.

INSERT FIGURE 6 HERE

To check whether the crisis was really at the heart of this short-lived rise, we explore some variants of this model by adjusting the size of the rolling window. We see in Figure 6 that the larger the size of the window (8 years and 10 years, compared to the benchmark 6 years), the slower the adjustment to pre-crisis level. This clearly supports the hypothesis that 2008-2009 crisis was behind the rise of integration. This result confirms the findings of Joyeux and Milunovich (2015) who note that "Interestingly, all of the convergence intervals coincide either with periods of crisis, or with periods of market exuberance. For instance, evidence of convergence is found during the 2000 dot-com crash, the 2007-2009 subprime crisis and the 2010-2013 European sovereign debt crisis, as well as over the bubble period of 2004-2005."

To further investigate these results, we test additional variants by adjusting the number of factors (3 versus 4 and 5 factors) to account for a potentially higher number of global sources of variations, and by comparing with models with factors lagged twice (6 months), 3 times (9 months) or with no lag at all, to explore the potential time delay in propagation of global shocks in the system. We see that the profile of the constructed R^2 time series is barely affected.

INSERT FIGURES 7 AND 8 HERE

5.3 Country specific analysis

The profile of the R^2s in Figure 6 is an average of the R^2s obtained for the 13 countries of our sample. We now look through the average in view to see if what we get at the aggregate level is well representative of what we get at the country level. Figures 9 and 10 show that the R^2s are generally high (above their average value), with sudden abrupt disconnections to very low values. It seems that idiosyncratic shocks have sudden disrupting effects on the country integration.

INSERT FIGURES 9 AND 10 HERE

To test whether integration is on the rise or stable, we regress the R^2 for each country on a linear trend during the years of data availability. We observe in Figure 11 that the R^2 has an upward trend in most countries (excepted Finland), that this trend is positive and significant at 5% in 9 countries (out of 13). We note that 3 of the 4 countries with no significant trend are Nordic countries, which suggests a potential regional logic that we investigate in Section 6. We also compared to alternative specifications with more factors and do not notice substantial changes (significance increases for some (France, Netherlands) and decreases slightly for some others (Belgium, United Kingdom).

INSERT FIGURE 11 HERE

6 Extensions

We address two key complementary questions, related firstly to the comparison of the integration of European real estate markets with non European markets, secondly to the emergence of potential regional dynamics via a cluster analysis. We finally discuss some additional robustness checks (based on quarterly variations instead of yearly variations and on ARMA filtering).

6.1 European versus non-European integration

We saw in the precedent Section the profile of the integration of European real estate markets over time. One motivation of the paper is to check whether European structural changes (single market, monetary union, post-crisis coordination of macroprudential policies) could be captured in the integration measures. However, changes in our integration measure profile might also be driven by global non European factors. We thus carry out a comparative analysis to assess whether the integration within Europe just reflects a world dynamics that we also find with non-European countries, in other words, to test whether integration within European countries has increased more than with non European ones.

We thus reiterate our estimations by regressing European property returns on global factors, which are now obtained from our correlation matrix of non European property returns. Global factors are now to be interpreted as non European factors, while global factors in precedent sections were "only" capturing commonality at the European level.

The evolution of the property returns series are reported in Figure 12 and descriptive statistics in Table 2. We see on these 47 years some isolated collapses in 1975 for New Zealand, 1982 for Australia, 1993 for Japan, 2008 for the US, with an apparent common upward trend in the last decade.

INSERT TABLE 2 AND FIGURE 12 HERE

The profile over time of the eigenvalues from the correlation matrix of non European property returns is quite different from the one obtained for European countries. We see in Figure 13 that the weight of the first factor declines, with the first factor going from a relative eigenvalue of 70% in the eighties to around 50% in the last decade. Remarkably, we also do not find the sharp rise around 2008 as was illustrated for European countries, which is not surprising as real estate markets of New Zealand, Japan, Australia and Canada were less strongly affected by the 2008 crisis (see Figure 12).

INSERT FIGURE 13 HERE

Quite interestingly, we see that the explanatory power of global factors has a very similar profile, no matter how we estimate the factors (European versus non European ones as illustrated in Figure 14). The integration seems to decline since the eighties until the 2008 crisis. The subprime crisis then strikes, as we see a sharp increase of integration from 2008 on. We finally see a progressive reversal of integration during the last decade. This comparative subsection does not support the hypothesis of a rising integration which would be specific to the European level. European diversification of real estate investments is still effective, not less than the international one.

INSERT FIGURE 14 HERE

Looking at country level, and coming as a nuance to our conclusions at the aggregate level, we see some difference in the country specific time-varying degree of integration. Indeed, only 5 of our 13 European housing return series have a significantly rising R^2. This contrasts with the findings obtained from our analysis based on European global factors where 9 of the 13 series had a significantly positive increase of integration. This once again highlights a potential regional pattern as Denmark, Finland and Norway are the ones with a significantly negative trend in integration. This regional dynamics will be discussed and analysed via clustering methods in the next subsection. This also relates to the degree of integration with non European countries which is higher than with European countries at the beginning of our time window (see Figure 14).

INSERT FIGURE 15 HERE

6.2 Regional integration

European housing markets are quite heterogeneous and we do not expect countries so distant as Spain and Finland to be closely integrated. Since the bottom line so far is that we do not find in the data a significantly rising integration at the European level (but only temporary around the 2008 crisis), and not stronger than integration with non European countries, we examine in this extension whether integration would emerge at the regional level. We thus rely on a clustering methodology (K-means clustering algorithm), which groups countries according to the similarity of their beta exposures to the global factors. Based on standard tools fo k-determination (Elbow method minimizing the total intra-cluster variation - or within-cluster sum of squares - and the Silhouette method maximizing the average silhouette coefficient Kaufman and Rousseeuw (1990)), we identify 3 clusters. We report in Figure 16 a map of Europe with colors corresponding to these 3 respective clusters. We also investigate the stability over time of the clusters (see Table 3). We find that clusters are not stable over time. We also isolate the Nordic countries (Denmark, Finland, Norway and Sweden) in Table 3 to see if they are characterized by some regional commonality, without success. The data do not support regional integration. European diversification also matters at regional level.

INSERT FIGURE 16 AND TABLE 3 HERE

6.3 Robustness complements

6.3.1 Quarterly and yearly variations

We reiterated this analysis by working with quarterly variations instead of yearly variations. The rationale behind our choice of annual variations was first to fix potential seasonality issues, and was then to enhance the capture of co-movement by allowing up to 3 quarters of delay between responses to shocks. Of course, the choice to work with annual variations of quarterly prices also artificially brings some autocorrelation in the data, thus noise in the regressions. To check, whether this choice had an impact on our results we reiterated the analysis with quarterly data and it turns out that the choice has barely any effect on the analysis outcomes.

6.3.2 ARMA filtering

Since the main input in principal component analysis is the covariance of our time series, a first key check is to make sure the covariance is stationary. The annual returns we use in this work are clearly found to be stationary according to the standard stationary tests. We go farther in this Section and filter the autocorrelation of our returns in view to make the series iid. The benefit of filtering the dynamic of the series is to improve the identification of the global factors. The downside is that the filter at the same time removes an autocorrelation that partially captures the effect of slowly propagating global factors shocks. Again, we investigate the effect on our results of ARMA filtering and find that the results remain barely unchanged, which suggests that the inclusions of lagged factors were enough to capture delayed effects of global factors.

7 Conclusions

The 2007-2008 financial crisis has given rise to a general increase in correlations of macro-financial indicators. Some investors had to cope with sudden loss of diversification power of their portfolios. Housing markets were not different. Correlations increased considerably around 2008.

The question is whether this rise was short-lived or whether something more fundamental changed in the real estate markets. Indeed, since 1999 the euro has been adopted as a common currency in many countries (19 countries in 2019). In addition, the European Systemic Risk Board, makes since 2010 common coordinated recommendations to most European countries (28 countries in 2019) on real estate market stability among others. Whether this higher regulatory integration gives rise to an acuter economic integration was our question.

We relied on the time-varying explanatory power of a linear multi-factor model to assess the degree of integration of the European housing markets. We find that the rise of integration subsequent to the 2007-2008 crisis was short-lived and that the average degree of integration comes back to a level, still a bit larger but, close to the pre-crisis one, despite a significant rise in integration in 9 of our 13 European countries. We compare the degree of within Europe integration with integration with the rest of the world and find that the time-varying profiles of integration are very similar, supporting the view that there is no recent change that would be specific to the European integration dynamics. We also find that real estate markets are not integrated at a regional level.

This paper could be extended in several directions. First, we work on country residential price series. More granular data isolating urban from rural areas would probably show different dynamics. Similarly, commercial real estate has a different and likely more integrated dynamics that would also deserve a specific analysis. Second, the evolution of integration is informative on diversification benefits, but this has not been specifically tested in this paper, and not been related to rebalancing strategies. This is certainly a promising next step. Third, the section devoted to regional clustering could be extended by considering spatial dependences based on distance or on common borders.

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Tables and Figures

Table 1: Descriptive statistics of real estate annual returns - Europe - 1972-2017

	Mean	SD	Skew	Kurt	Min	Max	Nobs
BE	1.094	4.922	-0.261	0.254	-10.841	15.620	184
CH	1.908	8.588	0.131	0.242	-17.675	27.933	184
DE	2.733	9.776	0.374	0.123	-18.167	33.185	184
DK	1.842	8.895	0.240	1.626	-21.141	34.094	184
ES	2.142	4.865	0.317	-0.481	-9.022	13.717	184
FI	3.808	9.719	0.510	0.777	-17.868	38.494	184
FR	2.944	9.365	-0.368	-0.068	-21.557	23.726	184
GB	1.786	7.156	1.582	3.465	-9.307	32.541	184
IE	2.706	8.690	0.387	2.215	-21.151	37.519	184
IT	3.374	7.988	-0.157	0.247	-18.115	25.205	184
NL	3.108	6.384	0.838	1.193	-9.639	28.173	184
NO	3.145	6.649	0.247	0.543	-16.034	23.590	184
SE	3.502	7.965	0.460	0.145	-12.132	28.683	184
Average	2.625	7.764	0.331	0.793	-15.580	27.883	184

Note: BIS real estate long price series, as CPI deflated. Annual percentage variations of quarterly data.

Table 2: Descriptive statistics of real estate annual returns - Non-Europe - 1972-2017

	Mean	SD	Skew	Kurt	Min	Max	Nobs
AU	2.360	5.151	-0.803	1.168	-13.414	12.747	184
CA	-0.082	2.510	0.440	-0.422	-4.901	6.040	184
JP	2.753	6.935	-0.698	0.105	-18.215	14.168	184
NZ	0.062	5.234	0.456	1.020	-14.312	17.596	184
US	1.794	5.712	-1.138	2.469	-19.926	12.994	184

Note: BIS real estate long price series, as CPI deflated. Annual percentage variations of quarterly data.

Table 3: Cluster analysis based on similarity of country exposures to global factors

	Full	77-90	91-04	05-17
BE	2	2	2	1
CH	2	2	1	3
DE	2	2	1	1
ES	2	2	1	1
FR	3	2	3	3
GB	3	3	1	1
IE	1	1	2	1
IT	3	3	1	3
NL	1	2	3	2
FI	3	3	2	3
DK	2	3	2	1
NO	3	3	1	3
SE	1	2	1	1

Note: Cluster analysis based on K-means algorithm where the partition of the 13 countries in 3 clusters is based on minimizing the within-cluster sum of squares of βs from equation 3. Values 1, 2 and 3 refer to the 3 specific clusters. Values are to be interpreted on a column basis only, as the attribution of values 1, 2 and 3 across the different sub-samples is arbitrary. Last four rows collect figures for the Nordic countries.

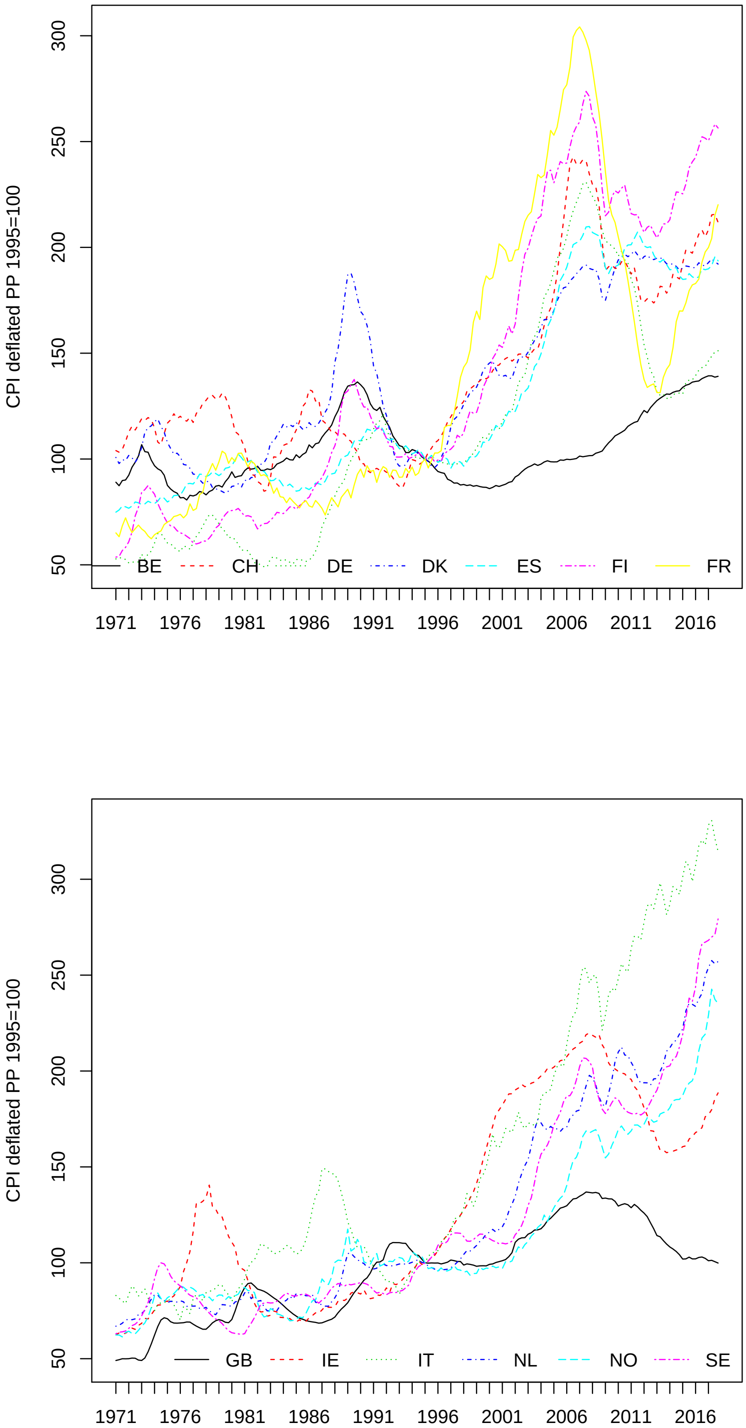


Figure 1: BIS Property Price Indices - CPI deflated series

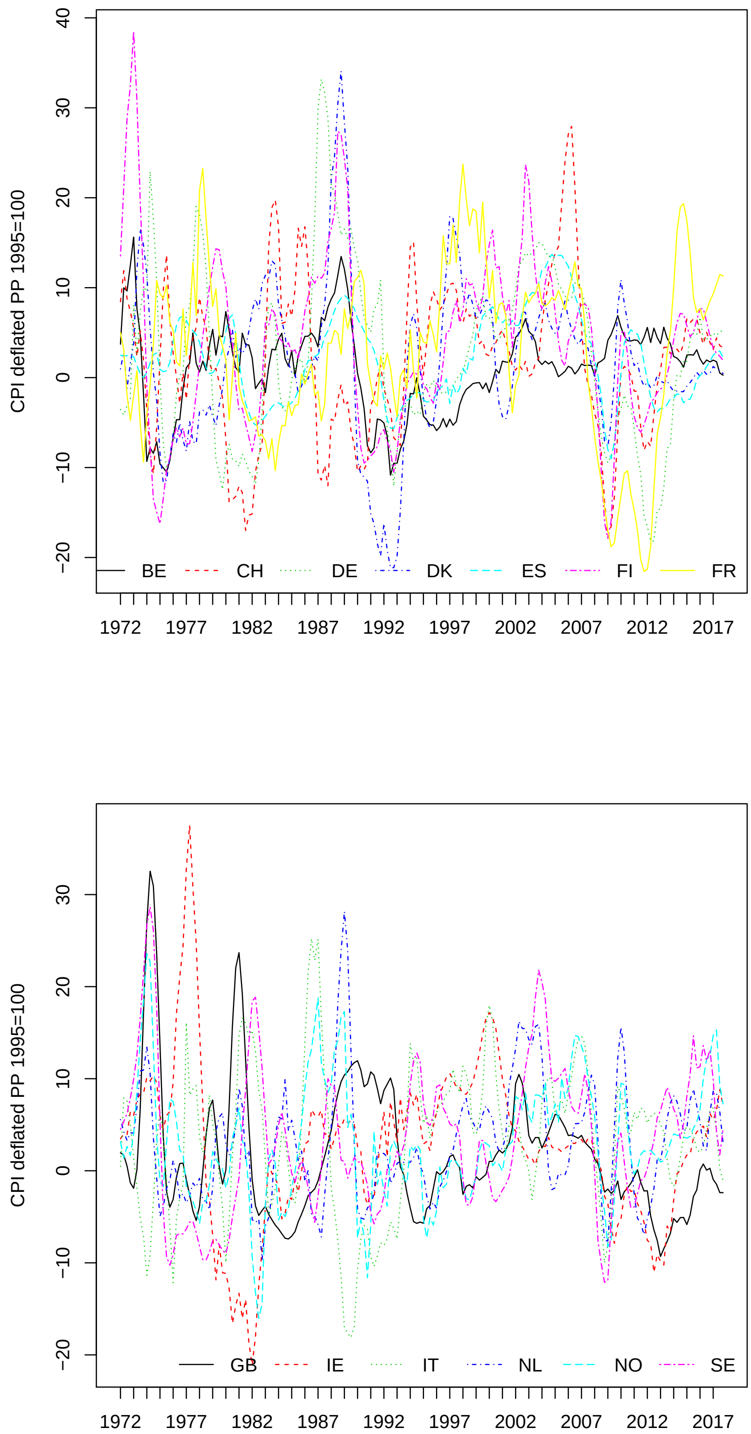
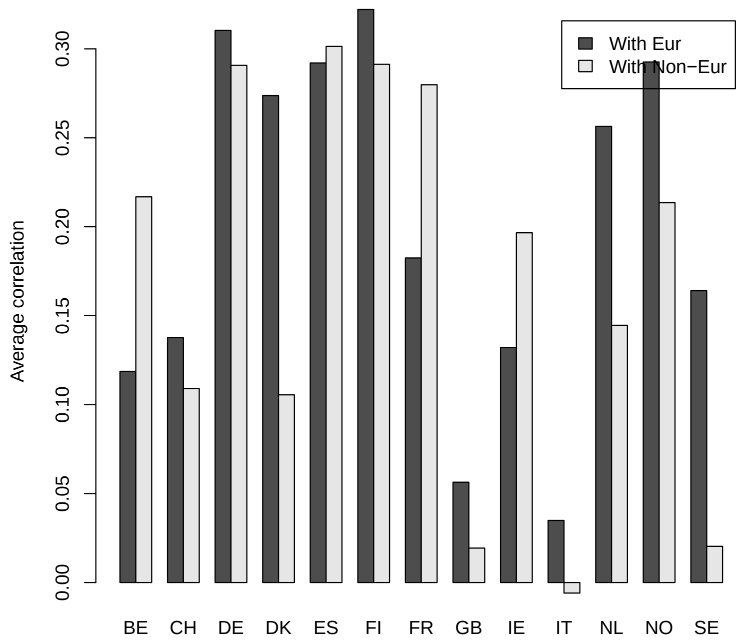
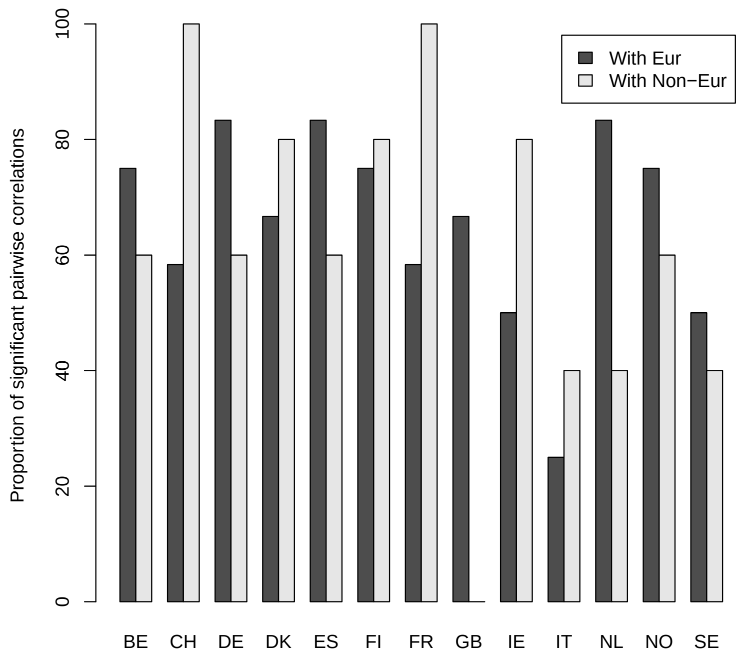


Figure 2: BIS Property Price Indices - annual percentage variations of CPI deflated series

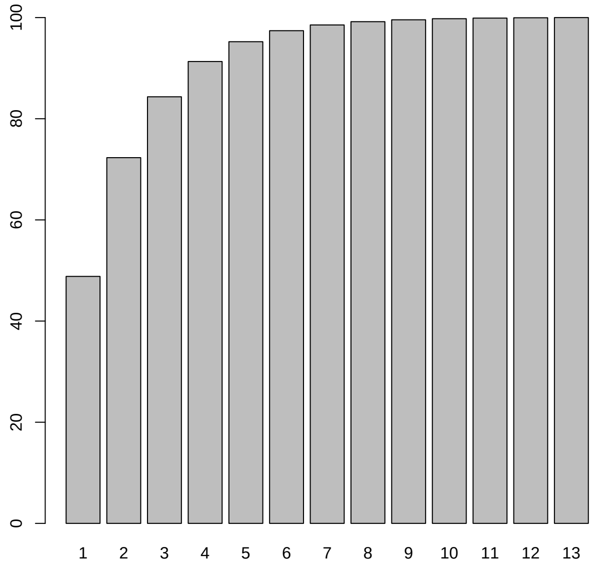


(a) Average pairwise correlations of European national real estate return series with series of Eur and non-Eur countries

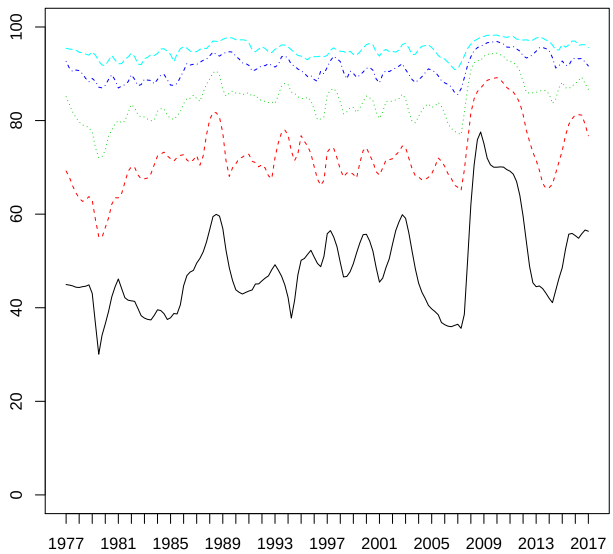


(b) Proportion of significant pairwise correlations real estate return series with series of Eur and non-Eur countries

Figure 3: Correlation analysis



(a) Average cumulative percentage of variance explained by sorted eigenvalues. The cumulative percentage of variance is explained within each estimation window of 6 years by spectral decomposition of the correlation matrix of the real estate annual returns. The average is taken over the 160 overlapping rolling windows.



(b) Stacked 5 largest eigenvalues as computed for each time window of 6 years by spectral decomposition of the correlation matrix of the real estate annual returns.

Figure 4: Eigenvalues analysis

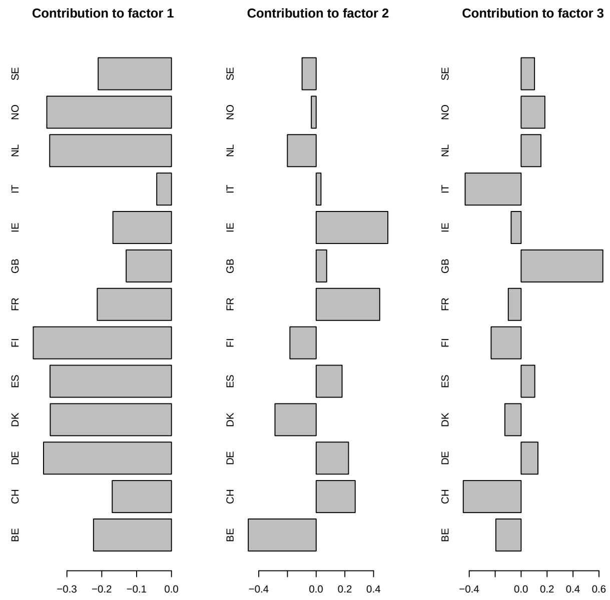


Figure 5: Eigenvectors associated to factors 1, 2 and 3. Values thus represent the country coefficients used in the linear combindations of national real estate returns designed to build factors 1, 2 and 3.

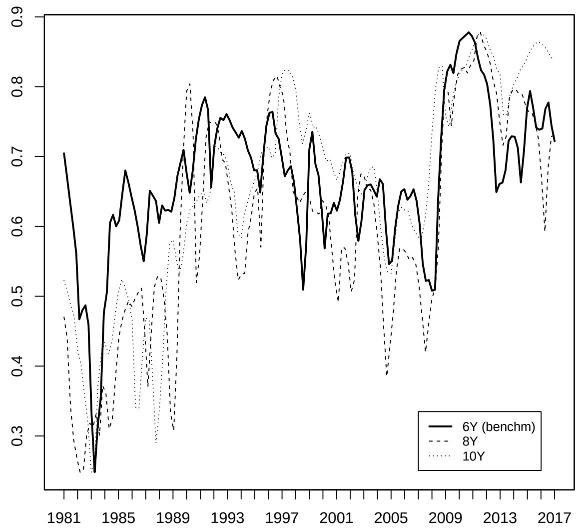


Figure 6: Indicators of global market integration. Our measure of market integration is the cross-country average of the adjusted R^2 from Equation 3. Comparison of the benchmark model (6-years window) with alternative estimation windows (8 and 10 years).

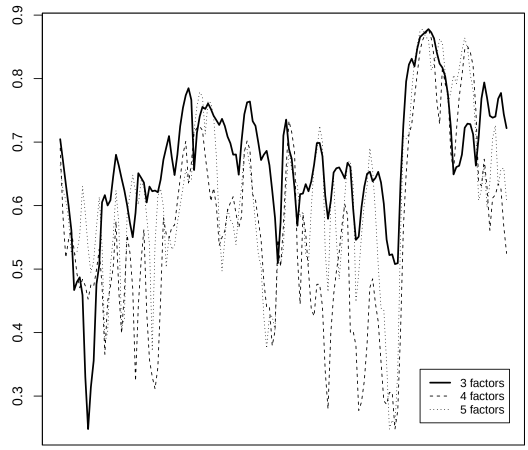


Figure 7: Indicators of global market integration. Our measure of market integration is the cross-country average of the adjusted R^2 from Equation 3. Comparison of the benchmark model (3 factors) with alternative number of factors (4 and 5 factors).

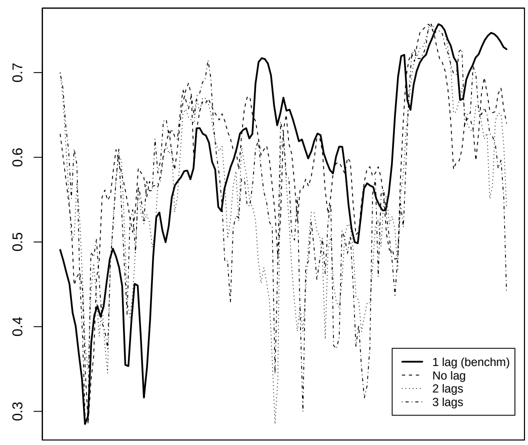


Figure 8: Indicators of global market integration. Our measure of market integration is the cross-country average of the adjusted R^2 from Equation 3. Comparison of the benchmark model (1 lag) with alternative number of lags (0, 2 and 3 lags).

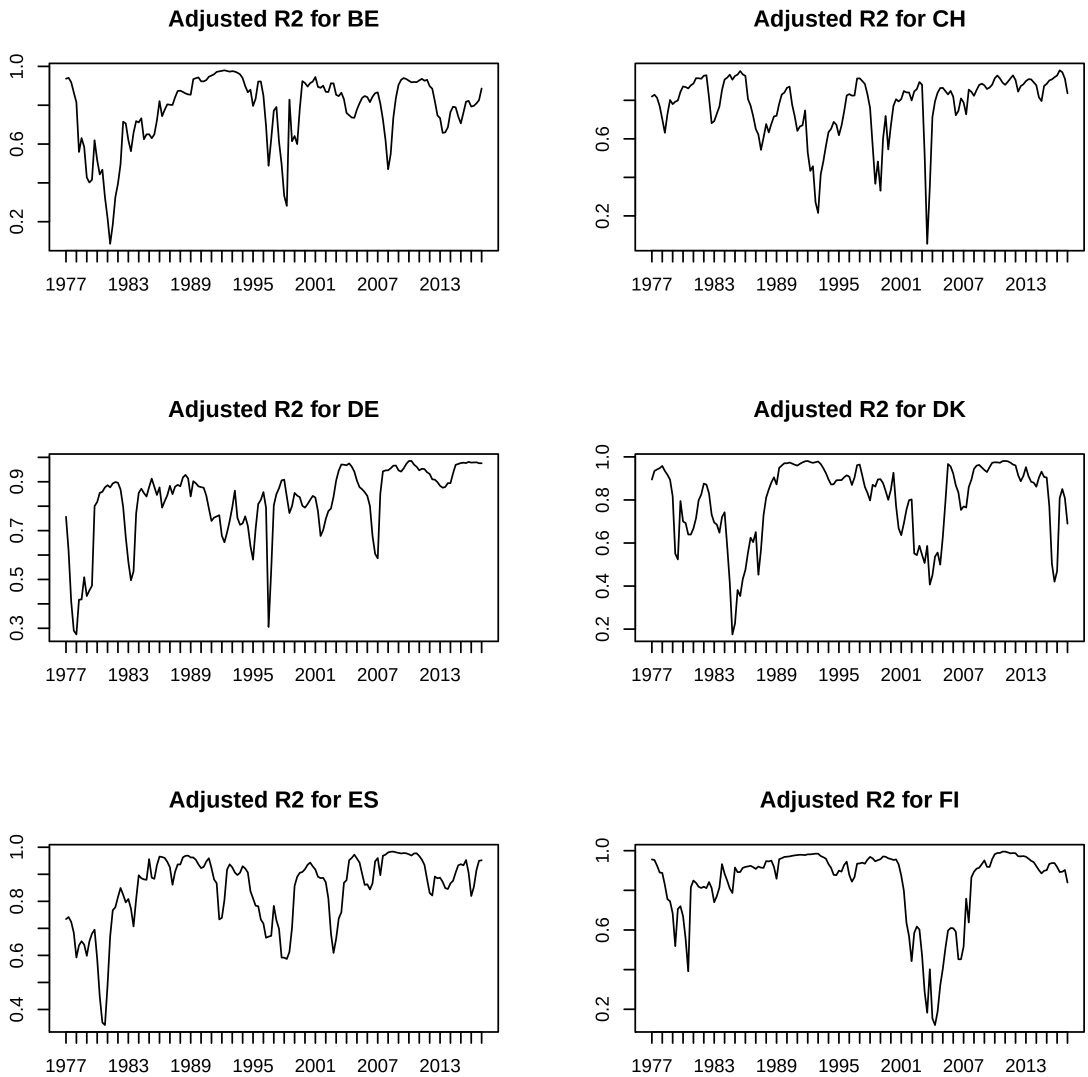


Figure 9: Indicators of global market integration. Our measure of market integration is the country specific adjusted R^2 as computed on 6 years windows (Equation 3) - 1/2

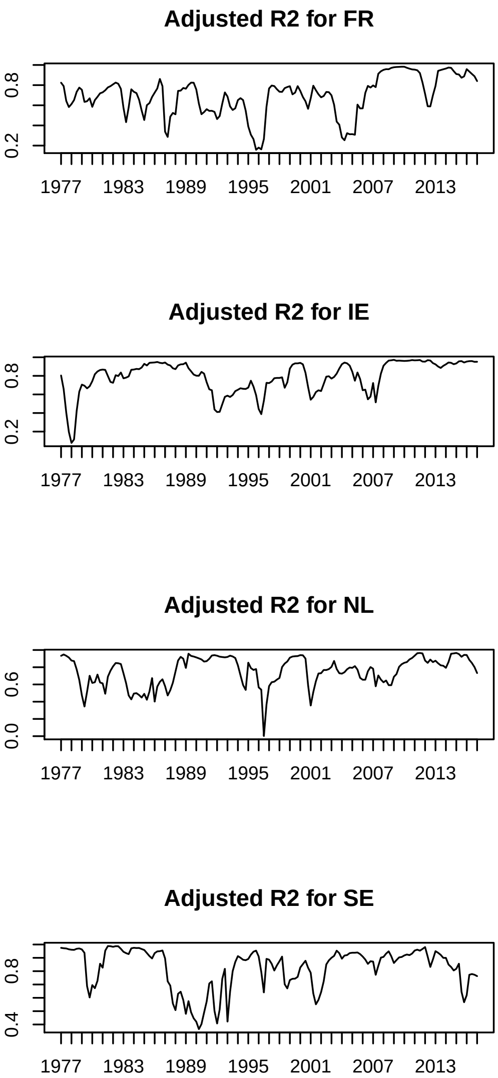


Figure 10: Indicators of global market integration. Our measure of market integration is the country specific adjusted R^2 as computed on 6 years windows (Equation 3) - 2/2

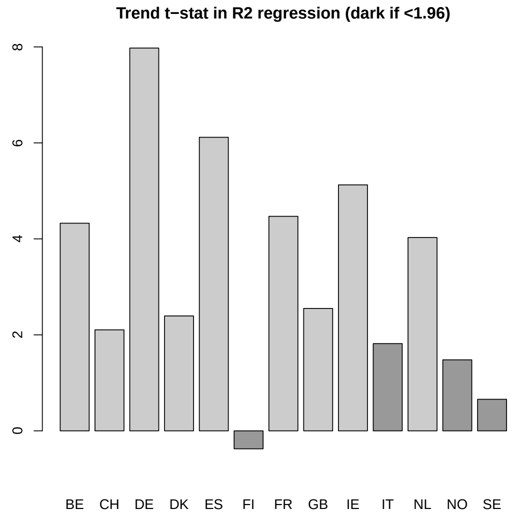


Figure 11: Time trend t-stats for adjusted R^2s from global factor models (Equation 3). Light grey if trend significant at 5%.

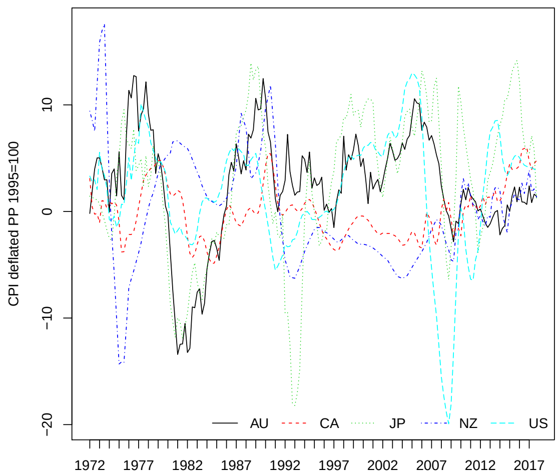


Figure 12: BIS Property Price Indices - annual percentage variations of CPI deflated series - Non-European countries

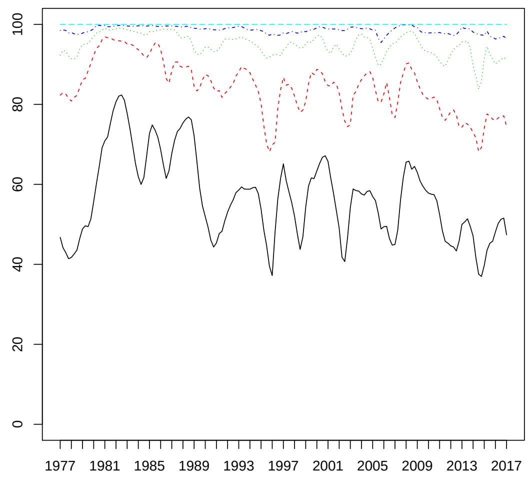


Figure 13: Stacked 5 eigenvalues as computed for each time window of 6 years by spectral decomposition of the correlation matrix of the real estate annual returns - Non-European countries

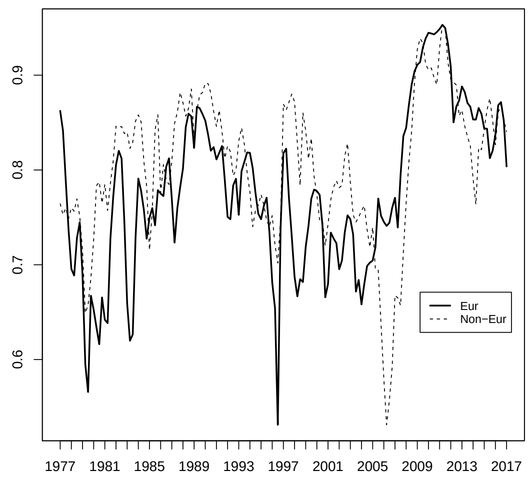


Figure 14: Indicators of global market integration. Our measure of market integration is the cross-country average of the adjusted R^2 from Equation 3. Comparison of the benchmark model (factors computed from the correlation matrix of European real estate returns) with global factor source (factors computed from the correlation matrix of non-European real estate returns).

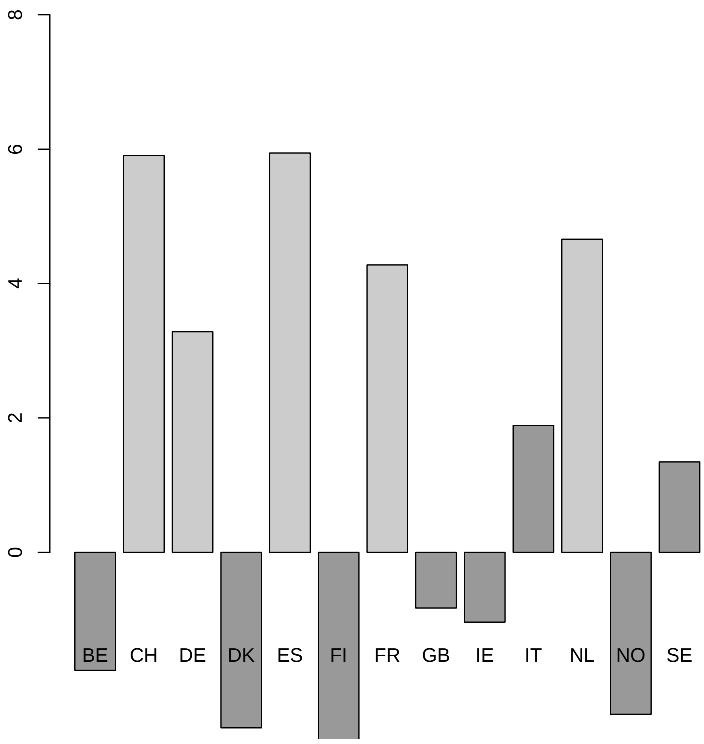


Figure 15: Time trend t-stats for adjusted R^2s from global factor models computed from the correlation matrix of Non-European real estate returns. Light grey if trend significant at 5%.

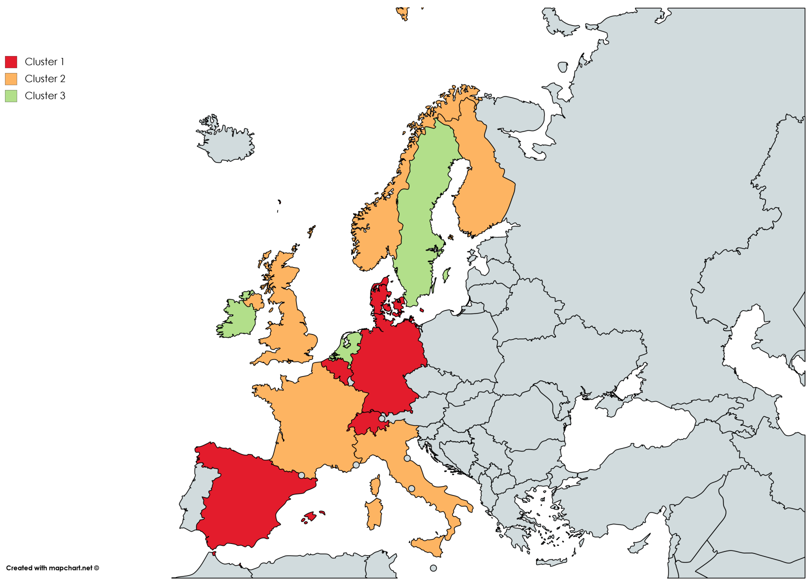


Figure 16: Map of the 3 European regional clusters resulting from the K-means algorithm, as applied on the full sample.