Int. Fin. Markets, Inst. and Money 22 (2012) 194–208

Contents lists available at SciVerse ScienceDirect

Journal of International Financial Markets, Institutions & Money

journal homepage: www.elsevier.com/locate/intfin

Changing integration of EMU public property markets

Nafeesa Yunus [a,*], Peggy E. Swanson [b,1]

[a] Department of Finance and Economics, Merrick School of Business, The University of Baltimore, Baltimore, MD 21201, United States
[b] Department of Finance and Real Estate, UTA Box 19449, The University of Texas at Arlington, Arlington, TX 76019, United States

ARTICLE INFO

Article history:
Received 7 June 2011
Received in revised form 30 August 2011
Accepted 6 September 2011
Available online 21 September 2011

JEL classification:
C5
E44
F33
F36
G15

Keywords:
Public property markets
European Monetary Union
Convergence
Recursive cointegration analysis
Granger causality

ABSTRACT

This paper examines the impact of the European Monetary Union (EMU) on European public property market integration. Results indicate that the property markets are long-run independent and show little evidence of short-run relationships prior to the formation of the EMU. However, the degree of interdependence and the extent of convergence among the largest property markets have intensified substantially after the launch of the Euro as the common currency in January, 1999. Moreover, each of the property markets under consideration is endogenous in that none is found to "dominate" the others toward long-run equilibrium. Short-run results indicate substantial interrelationships among the markets after the adoption of the Euro. Finally, the study shows that stock markets, bond markets, and public property markets follow similar convergence patterns.

1. Introduction

The degree to which international capital markets have become interrelated has long been a source of intrigue and interest to academics and practitioners alike (Koutmos and Booth, 1995; Booth et al., 1996, 1997; Kim et al., 2006a,b; Alexakis, 2010). The financial markets in the Euro-zone are especially appealing to study, because of the ongoing changes brought about by the economic and monetary unification process. Several studies have examined the impact of the European Monetary Union (EMU) on

* Corresponding author. Tel.: +1 817 319 3694.
E-mail addresses: nafeesa.yunus@gmail.com (N. Yunus), swanson@uta.edu (P.E. Swanson).
[1] Tel.: +1 817 272 3841.

1042-4431/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.intfin.2011.09.001

stock market and bond market linkages (Haug et al., 2000; Syriopoulos, 2006; Morelli, 2010; Demian, 2011), and most of these studies suggest that the EMU has significantly increased the degree of interdependence among member countries' equity and bond markets. Authors such as Holmes and Maghrebi, 2008, Lein et al. (2008) and Arghyrou et al. (2009) contend that these increasing dynamic interrelationships may be attributed primarily to economic convergence stimulated by the monetary and economic policy rules and criteria imposed by the Maastricht Treaty.

Most of the studies, have focused largely on equity markets and bond markets with little attention given to European public property markets. Specifically this paper analyzes the impact of the EMU (hereafter "EMU" is used to indicate implementation of the Euro in January of 1999) on European property market integration. In essence, it compares the dynamic interaction among the securitized property markets of six major EMU economies prior to and after the formation of the EMU and evaluates the changing extent of convergence among these markets. Evidence suggests that property markets tend to be affected by the same macroeconomic fundamentals that drive equities and bonds (McCue and Kling, 1994), hence, it is hypothesized that the degree of interdependence among the property stock markets within the Euro-zone has increased since the formation of the EMU and the launch of the common currency in January, 1999.[2]

This study makes important contributions to existing literature. It utilizes robust methodologies for a relatively long period of time (January 1990 to December 2007) to analyze and compare long-run interdependent relationships and short-run linkages among major EMU member property markets prior to and after the establishment of the EMU. Using recursive cointegration introduced by Hansen and Johansen (1999), it examines whether EMU member property markets have become increasingly convergent with the passage of time and especially after the adoption of the Euro in January, 1999.

Also, following Phylaktis and Ravazzolo (2005) the study examines whether one or more of the property markets can be regarded as primary "drivers" that dominate the other markets and binds them in long-run equilibrium relation(s). Next, it examines whether short-run causal relationships changed after formation of the EMU. And finally, the study analyzes whether the convergence pattern of European public property markets resembles those of the general stock markets or bond markets.

By focusing explicitly on the changing level of integration among the public property markets of major EMU economies, before and after the adoption of the Euro, this paper extends the work by authors such as Wilson and Okunev (1996), Wilson and Zurbruegg (2001), and Yunus (2009) who had examined the impact of globalization on the integration among major securitized property markets. Moreover, by examining the convergence pattern of the securitized property markets in comparison to those of the general equity markets and bond markets, this paper extends studies by Lizieri et al. (2002) and Yang et al. (2005) who had focused solely on the dynamic interactions among the real estate markets of major EMU economies. Further, by implementing robust econometric techniques and several relatively new diagnostic tests, the current study substantially improves on prior work that had evaluated interrelationships among the property markets of selected EMU economies.

The study offers some important implications. If the degree of integration among the property markets has intensified over time, and especially after the establishment of the EMU, such findings imply that the markets may be (increasingly) affected by the same economic stimuli, such that shocks to one market are easily propagated to other markets. This suggests that elimination of internal exchange rate risk as well as monetary and economic policy convergence have played a role in the increased property integration, reducing diversification benefits from investing in different major Euro member countries' property markets. Thus the findings will be beneficial to investors interested in allocating portfolio assets within the European securitized property sector and to EMU policymakers concerned with real property pricing in making better informed economic policy decisions.

The remainder of the paper is organized as follows: Section 2 presents a relevant literature review; Section 3 sets forth a brief description of the data; Section 4 discusses the methodology; Section 5 examines empirical results; and, finally, Section 6 contains concluding remarks.

[2] In this paper, the terms *public* property market and *securitized* property market are used interchangeably.

2. Literature review

Numerous studies such as Haug et al. (2000) Syriopoulos (2006), Morelli (2010) and Demian (2011) have examined the impact of the EMU on equity market and bond market linkages. Most of these studies find that equity markets of EMU member economies have become increasingly integrated, especially after the introduction of the Euro in January, 1999.

Several authors have taken the analysis a step further and contend that financial market integration among EMU member countries can be attributed primarily to economic interdependence resulting from macroeconomic harmonization brought about by various rules and policies stipulated by the Masstricht Treaty (see, for example, Haug et al., 2000; Syriopoulos, 2006; Holmes and Maghrebi, 2008; Lein et al., 2008; Arghyrou et al., 2009). Some of these authors' point out that since the EMU member stock markets are converging toward fewer numbers of common stochastic trends over time, the markets increasingly may be perceived as a single area for investment opportunities. Although global public property markets tend to be driven by the same economic fundamentals as stock markets (McCue and Kling, 1994), little is known about the extent of convergence related to EMU economies. The authors have been able to identify only two papers relating to real estate markets of EMU member countries after the establishment of the EMU.

A paper by Lizieri et al. (2002) investigate the effects of the EMU on the behavior of public property returns. Utilizing different statistical measures, they find that commercial real estate equity markets are less integrated than basic equity markets. They thereby argue that relative to wider equity markets, dispersion of performance is higher, correlations are lower and a common contemporaneous factor has much lower explanatory power while lead–lag relationships are stronger. The authors conclude that the transmission of monetary integration to real estate securities is less noticeable than to equity stocks and attribute their findings primarily to the size of the real estate securities market and the national (and often local) nature of the holdings.

Yang et al. (2005) also evaluate the impact of the European Monetary Union (EMU) on linkages among nine European public property markets. Their results indicate no difference in the extent of integration among the markets pre and post EMU. However utilizing short-term forecast variance decomposition measures, they find that the property markets of larger EMU countries have become more integrated with their other European counterparts after the establishment of the EMU, while the property markets of smaller EMU countries have not. Further, their analyses suggest that non-EMU member countries show little change or less integration.

Motivated by the findings in Lizieri et al. (2002) and Yang et al. (2005), we reinvestigate the dynamic interactions among the securitized property markets of major EMU economies. The main contributions of this current paper include, (a) evaluation and comparison of the extent of long-run relationships among the securitized property markets of major EMU economies prior to and after the formation of the EMU over a relatively long period of time, (b) analysis of the progression of linkages to visually identify the gradual and ongoing evolution of linkages among these property markets over time (c) implementation of improved and robust methodologies for analyzing univariate and multivariate long-run properties of the securitized property markets. (d) examination of short run relationships among the EMU member property markets before and after the adoption of the Euro and (e) analysis of the convergence pattern of EMU public property markets in comparison to those of EMU stock markets and bond markets.

3. Data

The data employed consists of publicly traded real estate stock price indices quoted on a weekly basis, provided by the European Public Real Estate Association (EPRA) and the National Association of Real Estate Investment Trusts (NAREIT) for the public property markets of six core EMU economies: Belgium, France, Germany, Italy, Netherlands and Spain. [3] Even though EPRA/NAREIT supplies data for

[3] Weekly frequency data are used since daily observations can prove problematic due to excess noise, non-synchronous trading and bid ask spreads.

property markets of several additional EMU member participants (such as Finland and Ireland), these markets are not included because of incomplete data.

The analysis is conducted for two sub-periods: pre-EMU period covers January 1990 to December 1998 and post-EMU period is from January 1999 to December 2007. These two sub-periods allows us to compare the dynamic interactions and extent of convergence among the pubic property markets prior to and after the formation of the EMU. All analyses are in local currency terms as well as in U.S. dollars. [4]

The EPRA/NAREIT indices are well regarded by academics and industry practitioners alike. They are comprised of the largest and the most heavily traded real estate stocks for each of the countries included and thus can be viewed as an objective and representative benchmark for the real estate market of a country (Yunus, 2009). Moreover, in a recent report, Barclays Global Investors (U.S.) compared various index providers. They found that the EPRA/NAREIT indices ranked high in terms of coverage, investability, liquidity, float adjustment, published rules, accuracy and institutional investor acceptance, issues critical to real estate investment.

4. Methodology

A number of relatively new time series techniques and diagnostic tests are applied to robustly evaluate the univariate and multivariate properties of the property markets under consideration. First, unit root tests determine the order of integration, followed by multivariate cointegration tests to identify long-run equilibrium relationship(s) among the markets. If evidence of cointegration is found, hypothesis tests are implemented to evaluate the markets that form the cointegration space and the markets that are weakly exogenous. Next, recursive cointegration provides for visual inspection of the progression of linkages among the property markets to ascertain whether the EMU member property markets are becoming increasingly convergent over time. And finally, short-run causality tests assess lead–lag relationships among the property markets.

4.1. Unit root tests

Before proceeding with cointegration analysis it must be established that at least two of the series are nonstationary data generating processes containing a single unit root (Hansen and Juselius, 2000). The Ng and Perron (2001) test is employed to evaluate the univariate stochastic properties of the indices. The test uses the Generalized Least Squares detrending procedure (developed by Elliott et al., 1996) to create "efficient" versions of the Phillips and Perron (1988) tests. The following two tests, collectively called as the Ng and Perron (2001) M tests are MZ_α and MZ_t:

$$MZ_\alpha = (T^{-1}y_t^2 - S_{AR}^2)\left(2T^{-2}\sum_{t=1}^{T} y_{t-1}^2\right)^{-1} \tag{1}$$

$$MZ_t = MZ_\alpha \times MSB \tag{2}$$

where T is the total number of usable observations, $y_t = u_t + d_t$, $d_t = \phi' z_t$, z_t is a set of deterministic components, $u_t = au_{t-1} + v_t$, S_{AR}^2 is an autoregressive estimate of the spectral density of frequency zero of v_t and

$$MSB = \left(T^{-2}\sum_{t=1}^{T}\frac{y_{t-1}^2}{S_{AR}^2}\right)^{1/2}.$$

Ng and Perron (2001) demonstrate that these M tests have similar power properties and superior size properties relative to the tests developed by Phillips and Perron (1988) when the lag length is chosen using the modified Akaike information criterion to avoid size distortions while maintaining

[4] For brevity, the results are reported only in U.S. dollars.

power. Based on these results, for the subsequent cointegration analysis, a property index is considered and included only if it is found to be nonstationary and integrated of order one, $I(1)$.

4.2. Cointegration tests

The maximum likelihood estimation technique developed by Johansen (1988) and Johansen and Juselius (1990) tests for the existence of long-run equilibrium relationships (cointegration) among the included markets. The the error correction model is:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-1} + \mu + \varepsilon_t \tag{3}$$

where Δ is the difference operator, X_t is an n dimensional vector of real estate stock price indices, Γ_i is an $n \times n$ coefficient matrix representing short-run dynamics while Π is an $n \times n$ matrix whose rank determines the number of distinct cointegrating vectors that exist among the variables in X_t. [5] Johansen suggests two test statistics to determine the rank of the Π matrix: the λ_{Trace} test and the λ_{Max} test:

$$\lambda_{Trace}(r) = -T \times \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{4}$$

$$\lambda_{Max}(r, r+1) = -T \times \ln(1 - \hat{\lambda}_{r+1}) \tag{5}$$

In these equations, T represents the number of usable observations, λ_i represents the eigenvalues obtained from the Π matrix and the significance of the λ_i determines the appropriate rank of the matrix. If evidence of cointegration is found, exclusion tests and tests of weak exogeneity are performed to analyze which of the property markets is participating in the cointegrating space and which of the markets is weakly exogenous. In essence if there are r cointegrating vectors, the Π matrix in Eq. (3) can be decomposed into two $n \times r$ matrices such that $\Pi = \alpha\beta'$ where β is the matrix comprised of the cointegrating parameters and α is the matrix composed of the speed of adjustment parameters. The exclusion tests can be conducted by restricting the corresponding row in the β matrix to zero while tests of weak exogeneity can be conducted by setting the relevant row of the α matrix to zero.

Further supporting investigation, however, is necessary because Gregory (1994) and Richards (1996), have contended that Johansen's (1988) and the Johansen and Juselius's (1990) Maximum Likelihood estimation techniques may lead to misleading conclusions regarding the number of CIVs. Hence, a relatively new diagnostic technique known as the recursive cointegration is implemented to augment the results of the standard Johansen's tests (Rangvid, 2001 and Hansen and Johansen, 1999). The recursive cointegration analysis evaluates the progression of linkages among the property markets over time and is conducted using the "R-representation" where the short run parameters are kept fixed to their full sample values and only the long-run parameters are re-estimated. Finally, recursive likelihood ratio tests ensure the constancy of the cointegration space and verifies the adequacy of the models.

4.3. The Granger causality tests and impulse response function analysis

Short term relationships are examined by means of multivariate Granger's causality tests (Granger, 1988) and impulse response function analysis. If the variables are found to be non-cointegrated, tests for causality are implemented using the following VAR:

$$X_t = \mu + \Gamma_1 X_{t-1} + \ldots \Gamma_p X_{t-p} + \varepsilon_t \tag{6}$$

where X_t is a $n \times 1$ matrix of endogenous variables, Γ_i, $i = 1 \ldots p$ (where p is the number of lags) is a $n \times n$ matrix consisting of beta coefficients, X_{t-i} is a $n \times 1$ matrix of the lagged endogenous variables

[5] In this paper, the likelihood ratio test advocated in Crowder and Wohar (1998) is used to compute the appropriate lag length of the Vector Auto Regression (VAR) and the subsequent Vector Error Correction Model (VECM).

and ε_t is a $n \times 1$ matrix of white noise error terms. On the other hand, if the variables are found to be cointegrated, then an error correction term is added:

$$X_t = \mu + \Gamma_1 X_{t-1} + \ldots + \Gamma_p X_{t-p} + \lambda \hat{e}_{t-1} + \varepsilon_t \quad (7)$$

where $\hat{e}_{t-1}$ represents the error correction term that measures the adjustment to deviations from long-run equilibrium. In addition to Granger causality tests, impulse response function (IRF) analysis is conducted for both the pre-EMU and post-EMU periods. The impulse response functions (IRFs) help (visually) examine the speed with which a one standard deviation shock in one market is transmitted to the other markets.

5. Empirical results

5.1. Unit root tests

Table 1 summarizes the results of the Ng and Perron (2001) unit root tests for the property markets of Belgium, France, Germany, Italy, the Netherlands and Spain. The null hypothesis of nonstationarity cannot be rejected for any of the series at the conventional level of significance. The results are consistent across each sub-period and are similar to those of Yang et al. (2005) who find unit roots in the securitized property indices of several European property markets. Since the property markets are found to be nonstationary, they are tested for cointegration.

5.2. Long-run analysis

5.2.1. Pre-EMU analysis of European property markets

The cointegration results presented in Table 2 support weak evidence of a single cointegrating vector (1 CIV) shared among the markets over the pre-EMU period. Even though the λ_{Max} test statistic points to the existence of a single cointegrating vector at the 10% level of significance, the λ_{Trace} test statistic shows no evidence of cointegration. However, λ_{Trace} statistic tends to have more power than the λ_{Max} statistic (Serletis and King, 1997) and thus, the results of the λ_{Trace} statistics are used instead. Both the λ_{Trace} and λ_{Max} test statistics are compared to their corresponding critical values in Osterwald-Lenum (1992).

Next, recursive cointegration analysis provides an additional diagnostic test to evaluate the multivariate properties of the markets. The recursive cointegration result for the pre-EMU era is shown in Fig. 1a and b. The recursive trace statistic is normalized by the 10% critical value such that the number

Table 1
Unit root tests of European public property indices.

Country	MZ_α	MZ_t
Pre-EMU 1990–1998		
LBG	−2.919	−0.956
LGM	−3.786	−1.201
LFR	−5.433	−1.648
LNL	−3.559	−1.125
LIT	−1.913	−0.901
LSP	−3.298	−1.102
Post-EMU (1999–2007)		
LBG	−1.277	−0.742
LGM	−2.415	−1.080
LFR	−1.629	−0.783
LNL	−2.053	−0.907
LIT	−1.065	−1.878
LSP	−1.221	−0.754

Notes: For the Ng-Perron MZ_t tests, the data have been detrended by the GLS procedure, while for the MZ_α the data have been demeaned. Critical values for the corresponding MZ_α and MZ_t statistics obtained from Ng and Perron (2001) are −17.30 and −2.91, respectively, at the 5% level.

Table 2
Johansen λ_{Max} and λ_{Trace} tests summary.

H_0	λ_{Max} test	H_0	λ_{Trace} test
Pre EMU (1990–1998)			
$r=0$	45.83[a]	$r=0$	98.96
$r=1$	29.17	$r\leq 1$	67.57
$r=2$	22.21	$r\leq 2$	48.40
$r=3$	12.48	$r\leq 3$	26.19
$r=4$	8.16	$r\leq 4$	13.70
$r=5$	5.55	$r\leq 5$	5.55

Source: Critical values have been obtained from Osterwald-Lenum (1992) (Table 1).
Notes: The null hypothesis is H_0 which tests for the number of cointegrating vectors (designated by r) is given by both the λ_{Trace} and λ_{Max} test statistics.
[a] Denotes significance at the 5% level.

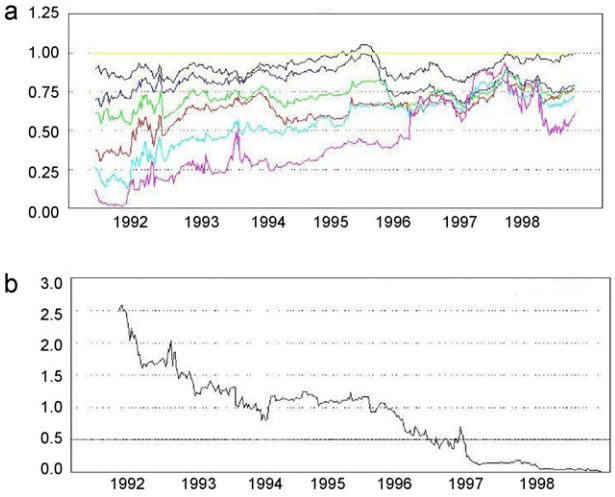

Fig. 1. (a) Recursive trace tests under the "R-representation". *Note*: For ease of interpretation, the test statistics in (a) has been scaled by their critical values such that the number of line(s) above 1.0 indicate the number of cointegrating relationship(s) at the 10% level of significance. (b) Recursive likelihood ratio test of the constancy of CIVs. *Note*: The test statistics in (b) is scaled by the 5% critical value such that a value greater than unity indicates the rejection of the null hypothesis that the parameters are constant over the period under consideration.

of trace statistics greater than 1.0 indicates the number of CIVs shared by the variables in the system, while the recursive likelihood ratio tests are normalized by the appropriate 5% critical value such that values below 1.0 indicate non-rejection of the null hypothesis that the cointegration space is stable or constant over time.

From Fig. 1a it appears that the trace statistic crosses the critical value of 1.0 for a brief period of time during 1994. It also hovers around the critical value (but does not necessarily cross it) toward the end of 1997. However, Fig. 1b clearly rejects the null hypothesis that the single CIV is stable since the critical value far exceeds the normalized value of 1.0 over the time period under consideration thus corroborating earlier results of the λ_{Trace} test.

Overall these results suggest that property markets are not bound together during the pre-EMU period, a finding in contrast to Yang et al. (2005) who show evidence of a single CIV among a group of European property markets prior to the formation of EMU. Our analysis emphasizes the importance of additional diagnostic tests to augment the conventional Johansen's test results.

Table 3
Granger causality tests (pre-EMU).

Dependent variables	Independent variables					
	ΔNL_t	ΔFR_t	ΔGM_t	ΔSP_t	ΔIT_t	ΔBG_t
ΔNL_t	–	0.426	0.853	0.318	0.464	0.172
ΔFR_t	0.238	–	0.609	0.288	0.759	0.804
ΔGM_t	0.196	0.316	–	0.661	0.628	0.495
ΔSP_t	0.133	0.105	0.564	–	0.527	0.168
ΔIT_t	0.713	0.618	0.465	0.728	–	0.433
ΔBG_t	0.573	0.142	0.981	0.117	0.241	–

Note: Δ denotes the difference operator.

Table 4
Johansen λ_{Max} and λ_{Trace} tests summary.

H_0	λ_{Max} test	H_0	λ_{Trace} test
Post-EMU (1999–2007)			
$r=0$	41.62[a]	$r=0$	124.59[a]
$r=1$	35.96[a]	$r\leq 1$	82.97[a]
$r=2$	29.13[a]	$r\leq 2$	57.01[a]
$r=3$	20.20[a]	$r\leq 3$	35.88[a]
$r=4$	10.18	$r\leq 4$	13.69
$r=5$	3.50	$r\leq 5$	3.50

Source: Critical values have been obtained from Osterwald-Lenum (1992) (Table 1).
Notes: The null hypothesis is H_0 which tests for the number of cointegrating vectors (designated by r) is given by both the λ_{Trace} and λ_{Max} test statistics.
[a] Denotes significance at the 5% level.

5.2.2. Short-run analysis

Even though the cointegration tests reveal no evidence of long-run relationships among the markets during the pre-EMU period, it is possible that short-run relationships exist. Granger causality test results presented in Table 3 indicate minimal lead lag relationships. The impulse response function (IRF) analysis for the pre-EMU period also indicate very little short-run relationships among the markets. [6] The lack of short-term relationships indicate that most of the markets are short-term independent and suggest that short-run diversification benefits are attainable within the Euro-area during this sub-period.

5.3. Long-run analysis

5.3.1. Post-EMU analysis of European property markets

Table 4 presents the results of conventional Johansen cointegration tests for the property stock markets post-EMU. Both the λ_{Trace} and λ_{Max} indicate 4 cointegrating vectors at the 5% level of significance. Thus, the cointegration results indicate that the EMU public property markets have become highly integrated during the post-EMU period.

5.3.2. Exclusion tests, tests of weak exogeneity and recursive cointegration tests

Table 5 identifies the excludable market and evaluates whether any of the property markets can be regarded as the source of the common trend. Panels A and B in Table 5 repeat the Johansen λ_{Trace} and λ_{Max} statistics and indicate the existence of four CIVs when all the property markets are incorporated in the system. However, the exclusion tests results in Panel C show that the property market of Spain can be excluded from the cointegration space. The fact that the null hypothesis of $\beta_{SP}=0$ cannot be rejected suggests that the market of Spain is not part of the four cointegrating vectors shared among the property markets of Belgium, France, Germany, Italy and the Netherlands.

[6] The IRF graphs are not reported to conserve space but are available upon request.

Table 5
Exclusion tests and tests of weak exogeneity (post-EMU).

Panel A	λ_{Trace}					
Countries	$H_0: r=0$	$H_1: r\leq 1$	$H_2: r\leq 2$	$H_3: r\leq 3$	$H_4: r\leq 4$	$H_5: r\leq 5$
All markets	124.59[d]	82.97[d]	57.01[d]	33.88[d]	13.69	3.50
Excluding SP	99.08[d]	57.94[d]	34.16[d]	18.59[d]	3.21	
Panel B	λ_{Max}					
Countries	$H_0: r=0$	$H_1: r=1$	$H_2: r=2$	$H_3: r=3$	$H_4: r=4$	$H_5: r=5$
All markets	41.62[d]	35.96[d]	29.13[d]	20.20[d]	10.18	3.50
Excluding SP	41.14[d]	23.79[d]	19.57[d]	11.38[d]	3.21	
Panel C[a]	Exclusion					
	BG	GM	FR	NL	IT	SP
(a) $\beta_i=0$	18.52[d]	11.83[d]	21.28[d]	29.06[d]	16.03[d]	3.30
Panel D[b]	Test statistic					
(b) $\beta_{SP}=0$	0.51					
Panel E[c]	Weak exogeneity					
	BG	GM	FR	NL	IT	SP
(c) $\alpha_i=0$						
Non-excludable markets	29.28[d]	18.70[d]	19.84[d]	33.78[d]	17.81[d]	–

[a] Property index i can be excluded from the cointegration space. The test statistic is $\chi^2(r)\times[n-(n-m)]$ where n is the number of variables in the VAR and m is the number of restrictions in the system.
[b] The Spanish property index is excludable from the cointegration space. The test statistic is $\chi^2(r)\times[n-(n-m)]$ where n is the number of variables in the VAR and m is the number of restrictions in the system.
[c] Property index i is weakly exogenous. The test statistic is $\chi^2(r)\times[n-(n-m)]$ where n is the number of variables in the VAR and m is the number of restrictions in the system.
[d] Denotes significance at the 5% level.

The lack of linkages between Spain and the other European property markets may be attributed to the low level of securitization of the Spanish property sector. Relative to the other countries that already had an established REIT structure, Spain has yet to introduce and enact REIT legislation. The small size (in terms of market capitalization) of the Spanish property market relative to the other European markets and the weak state of the Spanish economy in general suggest additional differences. Also, while the other countries had liberalized their markets by the 1990s, Spain had just begun launching liberalization measures toward the beginning of the decade. These structural differences may offer reasons why Spain does not belong in the cointegration space spanned by its more mature counterparts. Thus, real estate investors within the Euro-zone can exploit long-run diversification benefits by investing in the Spanish property market.

Next, tests of weak exogeneity examine which of the markets do not respond to deviations from the long-run equilibrium relationship and thereby contribute to the common trends. Results shown in Panel E indicate that the none of the property markets can be considered weakly exogenous; the null hypothesis of weak exogeneity is rejected for each of the property markets at the conventional levels of significance. This suggests that all of the property markets are endogenous in that even though they do not individually contribute to the common trends, collectively their linear combination forms a single common stochastic trend that drives the system over time. Thus, none of the EMU public property markets can be considered as the primary "driver" market that leads the other markets toward long-run equilibrium.

Recursive cointegration tests evaluates the extent of convergence among the property markets over time when evidence of one or more cointegrating vectors is detected. Essentially, if the number of cointegration vectors increases with the passage of time, the implication is that the property markets are becoming increasingly integrated, suggesting a higher degree of convergence over time.

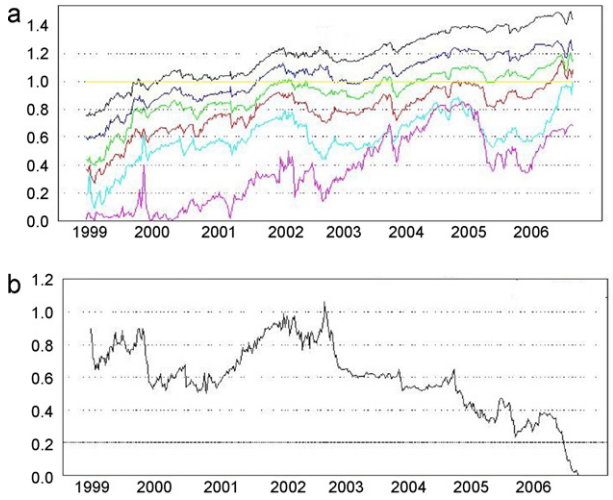

Fig. 2. (a) Recursive trace tests under the "R-representation". *Note*: For ease of interpretation, the test statistics in Fig. 2a has been scaled by their criticalvalues such that the number of line(s) above 1.0 indicate the number of cointegratingrelationship(s) at the 10% level of significance. (b) Recursive likelihood ratio test of the constancy of CIVs. *Note*: The test statistics in Fig. 2b is scaled by the 5% critical value such that a value greater than unity indicates the rejection of the null hypothesis that the parameters are constant over the period under consideration.

The results of the recursive trace tests and the recursive likelihood ratio tests are depicted in Fig. 2a and b respectively. Fig. 2a indicates there are indeed four cointegrating vectors shared among the six property markets. The first cointegrating vector becomes statistically significant and surfaces toward 1999 coinciding with the establishment of EMU and the introduction of Euro as the single currency, the second cointegrating vector emerges during 2002 corresponding to the circulation of the Euro as the common currency, while the third and the fourth cointegrating vectors appear toward 2004 and 2006, respectively, suggesting increased integration and convergence among the member property markets (Rangvid, 2001). Finally, Fig. 2b indicates that the 4 CIVs specification is appropriate for the system.

In summary, the results of the recursive technique as well as the standard Johansen approach indicate that the property markets of Belgium, France, Germany, Italy, and the Netherlands have become increasingly integrated over time and especially after the formation of EMU and the introduction of the Euro in January of 1999. Thus the Spanish property market provides the greatest long-run diversification benefits for investments within the Eurozone.

5.3.3. Short-run analysis

Cointegration implies causality in at least one direction (Granger, 1988) and since long-run relationships among the property markets have been established during the post-EMU period, an examination of the short-run dynamics among these markets merits attention. As advocated by Granger (1988), in a multivariate setting and in the presence of one or more cointegrating vectors, short-term "causal" linkages among the variables are measured using the Vector Error Correction model given above in Eq. (7). Within his model, Granger (1988) explains there are two possible sources of causation of the dependant variable by the independent variables: (1) through the lagged values of the independent variables and (2) through the error correction term(s).

The Granger causality results are presented in Table 6 and show substantial lead–lag relationships among the markets with the exception of Spain that neither causes nor is caused by any of the other property markets. For the remaining cointegrated markets, the coefficients of the independent variables are significant in several cases while the error correction coefficients are statistically significant in each of the equations, suggesting substantial bi-directional causality among all of the cointegrated

Table 6
Granger causality tests (post-EMU).

Dependent variables	Independent variables									
	ΔNL_t	ΔFR_t	ΔGM_t	ΔSP_t	ΔIT_t	ΔBG_t	*ECT1 PVal.*	*ECT2 PVal.*	*ECT3 PVal.*	*ECT4 PVal.*
ΔNL_t	–	0.005[a]	0.772	0.314	0.040[a]	0.775	0.537	0.000[a]	0.935	0.000[a]
ΔFR_t	0.446	–	0.070[a]	0.283	0.211	0.559	0.005[a]	0.285	0.078[a]	0.692
ΔGM_t	0.317	0.458	–	0.706	0.071[a]	0.786	0.013	0.09[a]	0.041[a]	0.815
ΔSP_t	0.317	0.587	0.981	–	0.655	0.927	–	–	–	–
ΔIT_t	0.030[a]	0.097[a]	0.022[a]	0.139	–	0.086[a]	0.008[a]	0.109	0.006[a]	0.759
ΔBG_t	0.048[a]	0.076[a]	0.467	0.290	0.812	–	0.004[a]	0.551	0.053[a]	0.043[a]

Note: Δ denotes the difference operator. NL ⇔ FR; NL ⇔ GM; NL ⇒ SP; NL ⇔ IT; NL ⇔ BG; FR ⇔ GM; FR ⇒ SP; FR ⇔ IT; FR ⇔ BG; GM ⇒ SP; GM ⇔ IT; GM ⇔ BG; IT ⇔ BG.

[a] Denotes statistical significance at the 5% level.

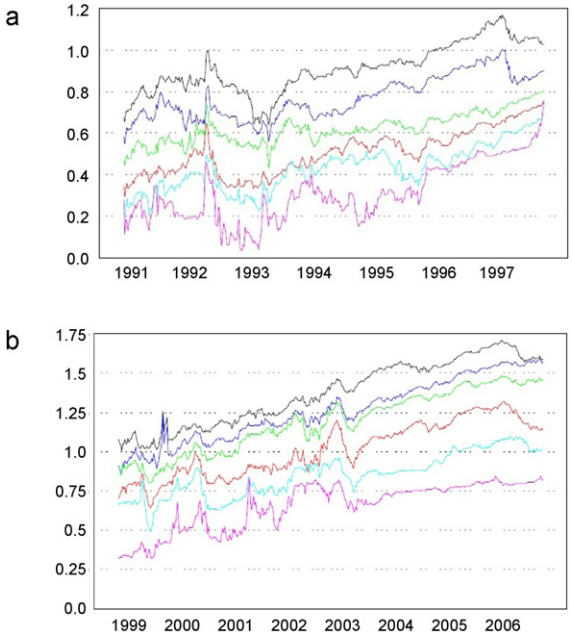

Fig. 3. (a) Recursive trace tests under the "R-representation" for Stocks (pre-EMU). (b) Recursive trace tests under the "R-representation" for Stocks (post-EMU). *Note*: For ease of interpretation, the test statistics in Fig. 3a and b, has been scaled by their critical values such that the number of line(s) above 1.0 indicate the number of cointegrating relationship(s) at the 10% level of significance.

property markets. [7] Next, results of the IRF analysis also indicate substantial interactions among all markets. [8] The only exception is Spain which responds minimally to shocks from the other property markets during the post-EMU period. Overall, the findings of the short-run analysis suggest that short-run diversification opportunities within the EMU are possible only in the Spanish property market after the advent of the Euro in January, 1999.

[7] It is important to note that the Spanish market can only influence the other variables through the joint significance of the coefficients on ΔSP because the error correction term does not open up a second channel of causality since this market is not part of any of the four cointegrating vectors.

[8] The IRF graphs are not reported to conserve space but are available upon request.

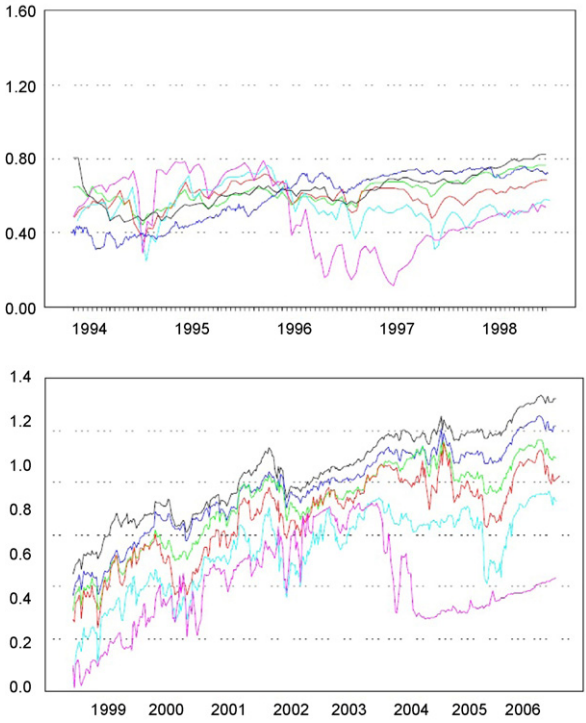

Fig. 4. (a) Recursive trace tests under the "R-representation" for Bonds (pre-EMU). (b) Recursive trace tests under the "R-representation" for Bonds (post-EMU). *Note*: For ease of interpretation, the test statistics in Fig. 4a and b, has been scaled by their critical values such that the number of line(s) above 1.0 indicate the number of cointegrating relationship(s) at the 10% level of significance.

5.4. Convergence patterns of EMU stock markets and bond markets

An important issue that is not well explored in the literature is how much the increasing convergence pattern of European real estate stocks (which is often considered a hybrid of stocks and bonds) would resemble that of general stock markets or bond markets. [9] Thus, in this section, we utilize the recursive cointegration technique to visually analyze the progression of linkages among the stock markets and bond markets of the EMU economies considered in the study (Belgium, Netherlands, France, Italy, Germany, and Spain) over the pre-EMU period and post-EMU period. Furthermore, we also discuss how the level of integration among these markets compares to that of the securitized property markets analyzed earlier in the study.

Fig. 3a and b depicts the evolution of linkages among the stock markets of the six major EMU economies over the pre-EMU and the post-EMU periods respectively. Fig. 3a reveals that the equity markets are bound together by only a single cointegrating vector over the pre-EMU period. Fig. 3b, shows that the equity markets are bound together by five cointegrating vectors suggesting a increased level of convergence among the EMU stock markets during the post-EMU period.

Next, Fig. 4a and b depicts the extent of convergence among the bond markets of the EMU economies over the pre-EMU and the post-EMU periods respectively. Fig. 4a shows that the bond markets are not cointegrated over the pre-EMU period. Fig. 4b, however signifies that the bond markets are bound

[9] We thank an anonymous referee profusely for making this crucial point.

together by four cointegrating vectors suggesting a high degree of integration among the bond markets during the post-EMU sub-period. [10]

In summary, the results of this section suggest that the equity markets and bond markets have become increasingly convergent after the inception of EMU implying that limited diversification benefits can be achieved by investing across the stock markets and bond markets of major EMU economies. These results are consistent with those found in recent studies that had utilized different sets of statistical techniques and had also concluded increased integration among the equity markets and bond markets of EMU economies after the inception of the EMU. [11]

The findings of this section also indicate that the convergence patterns of the securitized property markets analyzed earlier in Section 5.3.2 is very similar to those of the stock and bond markets since the extent of linkages among the securitized property markets have also intensified significantly during the post-EMU period. Numerous studies have shown that reduction of exchange-rate volatility as well as macroeconomic convergence have been the central driving force behind the stock/bond market integration process in Europe (Haug et al., 2000; Syriopoulos, 2006; Holmes and Maghrebi, 2008; Lein et al., 2008; Arghyrou et al., 2009). Thus, the findings of the current study extend the literature on European financial market integration by indicating that EMU has also been instrumental in increasing the extent of convergence among securitized property markets.

6. Conclusions

This paper analyzes the impact of the EMU on European public property market integration. It contributes to the literature by: (a) evaluating and comparing the extent of long-run relationships among the securitized property markets of major EMU economies prior to and after the adoption of the Euro over a relatively long period of time, (b) analyzing the progression of linkages among these markets to identify the gradual and ongoing evolution of linkages over time (c) utilizing improved and robust methodologies for analyzing univariate and multivariate properties of the securitized property markets, (d) examining short-run relationships among the EMU member property markets over time and (e) analyzing the convergence pattern of EMU public property markets in comparison to those of the EMU stock markets and bond markets. The countries included are Belgium, Germany, France, Netherlands, Italy and Spain, and the property markets are studied over two sub-periods: January 1990 to December 1998 as the pre-EMU period and January 1999 to December 2007 as the post-EMU period.

The findings are based on weekly real estate stock price data provided by EPRA/NAREIT and can be summarized as follows: There is no evidence of long-run relationships among the European property markets prior to the establishment of the EMU. Although the standard Johansen's cointegration approach shows some (weak) evidence of a single cointegrating vector, diagnostic test results reveal the absence of any long-run relationship. Results of short-run tests also indicate few lead–lag relationships among the markets. Prior to the introduction of the Euro in 1999, investors within the European Union could exploit both long-run and short-run diversification benefits by investing within the Euro-zone.

After the EMU, however, each of the property markets (with the exception of Spain) is bound together, sharing four long-run equilibrium relationships. Further, weak exogeneity tests indicate that each of the markets is unresponsive to deviations from the four long-run equilibrium relationships; therefore, none can be considered as the "dominant" influential market driving other markets. Thus, real estate investors within the Euro-zone can best exploit long-run profitable diversification opportunities only in the Spanish property market.

[10] It is important to note that none of the equity markets or bond markets are found to be excludable during the post-EMU period. Furthermore, the recursive likelihood ratio tests indicate that the models utilized for equity markets and the bond markets are adequate at the conventional level of significance. These results are not reported to conserve space and are available upon request.

[11] See for example, Billio and Pelizzon (2003), Kim et al. (2005), Pagano and Thadden (2004), Hardouvelis et al. (2006), Kim et al. (2006a,b), and Christiansen (2007) among numerous others.

Recursive cointegration results reveal that linkages among the (cointegrated) markets have increased over time, especially after the inception of the EMU and the adoption of the Euro in 1999. The first cointegrating vector surfaces toward the the middle 1999, coinciding with the establishment of the EMU and the introduction of the Euro; the second emerges during 2002, corresponding to the circulation of the Euro; and the third and fourth appear toward 2004 and 2006, respectively, possibly reflecting increased integration and convergence among the member property markets over time. Next, short-run results indicate substantial lead–lag relationships among all the property markets with the single exception of Spain implying that short-run diversification benefits can be attained only in the Spanish property market.

Finally, the study shows that, the convergence pattern of the securitized property markets is very similar to those of the stock and bond markets; the extent of linkages among all three financial markets have intensified significantly especially after the establishment of the EMU. Increased integration of all asset markets, including public property markets, may be attributed partially to the elimination of internal exchange rate risk and monetary policy convergence.

This study enriches the thin body of literature on European public property markets and benefits portfolio managers, pension fund managers and other institutional investors who are contemplating allocating a portion of their portfolios to the European securitized property sector. EMU policymakers also should benefit from better understanding of real property pricing when they make economic policy decisions. Investors may view the major (cointegrated) property markets in the Euro area basically as a single area or market for investment opportunities, while EMU policymakers may find it increasingly optimal to pursue and adopt Euro-zone wide real property policies in the future.

Acknowledgements

We are grateful to Professor Geoffrey Booth (Editor), and an anonymous referee for their valuable comments, suggestions and advice.

References

Alexakis, C., 2010. Long-run relations among equity indices under different market conditions: implications on the implementation of statistical arbitrage strategies. Journal of International Financial Markets, Institutions and Money 20, 389–403.
Arghyrou, M.G., Gregoriou, A., Kontonikas, A., 2009. Do real interest rates converge? Evidence from the European Union. Journal of International Financial Markets, Institutions and Money 19, 447–460.
Billio, M., Pelizzon, L., 2003. Volatility and shocks spillover before and after EMU in European stock markets. Journal of Multinational Financial Management 13, 323–340.
Booth, G.G., Leeb, T.H., Tsec, Y., 1996. International linkages in Nikkei Stock Index futures markets. Pacific-Basin Finance Journal 4, 59–76.
Booth, G.G., Martikainen, T., Tsec, Y., 1997. Price and volatility spillovers in Scandinavian stock markets. Journal of Banking and Finance 21, 811–823.
Christiansen, C., 2007. Volatility spillover effects in European bond markets. European Financial Management 13, 923–948.
Crowder, W.J., Wohar, M.E., 1998. Cointegration, forecasting and international stock prices. Global Finance Journal 9, 181–204.
Demian, C.V., 2011. Cointegration in Central and East European markets in light of EU accession. Journal of International Financial Markets, Institutions and Money 21, 144–155.
Elliott, G., Rothenberg, T.J., Stock, G.H., 1996. Efficient tests for an autoregressive unit root. Econometrica 64, 813–836.
Granger, C.W.J., 1988. Some recent developments in the concept of causality. Journal of Econometrics 39, 199–211.
Gregory, A.W., 1994. Testing for cointegration in linear quadratic models. Journal of Business and Economic Statistics 12, 347–360.
Hansen, H., Johansen, S., 1999. Some tests for parameter constancy in cointegrated VAR models. Econometrics Journal 2, 306–333.
Hansen, H., Juslius, K., 2000. Manual to Cointegration Analysis of Time Series CATS in RATS. Institute of Economics, University of Copenhagen.
Hardouvelis, G.A., Malliaropulos, D., Priestley, R., 2006. EMU and European stock-market integration. Journal of Business 79, 365–392.
Haug, A.A.M., MacKinnon, J.G., Micehlis, L., 2000. European monetary union: a cointegration analysis. Journal of International Money and Finance 19, 419–432.
Holmes, M.J., Maghrebi, N., 2008. Is there a connection between monetary unification and real economic integration? Evidence from regime-switching stationarity tests. Journal of International Money and Finance 27, 958–970.
Johansen, S., 1988. Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control 12, 231–254.
Johansen, S., Juselius, K., 1990. Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics 52, 169–210.
Kim, S.J., Lucey, B.M., Wu, E., 2006a. Dynamics of bond market integration between established and accession European Union countries. Journal of International Financial Markets, Institutions and Money 16, 41–56.

Kim, S.J., Moshirian, F., Wu, E., 2005. Dynamic stock-market integration given by the European Monetary Union: an empirical analysis. Journal of Banking and Finance 29, 2475–2502.
Kim, S.J., Moshirian, F., Wu, E., 2006b. Dynamics of bond market integration between established and accession European Union countries. International Financial Markets, Institutions and Money 16, 41–56.
Koutmos, G., Booth, G.G., 1995. Asymmetric volatility transmission in international stock markets. Journal of International Money and Finance 14, 747–762.
Lein, S.M., Leon-Ledesma, M.A., Nerlich, C., 2008. How is real convergence driving nominal convergence in the new EU member states? Journal of International Money and Finance 27, 227–248.
Lizieri, C., McAllister, P., Ward, C., 2002. Continental shift? An analysis of convergence trends in European real estate equities. Journal of Real Estate Research 25, 1–21.
McCue, T.E., Kling, J.L., 1994. Real estate returns and the macro economy: some empirical evidence from real estate investment trust. Journal of Real Estate Research 9, 277–288.
Morelli, D., 2010. European capital market integration: An empirical study based on a European asset pricing model. Journal of International Financial Markets, Institutions and Money 20, 363–375.
Ng, S., Perron, P., 2001. Lag length selection and the construction of unit root tests with good size and power. Econometrica 69, 1519–1554.
Osterwald-Lenum, M., 1992. A Note with quartiles as the asymptotic distribution of the maximum likelihood cointegration rank test statistics. Oxford Bulletin of Economics and Statistics 54, 461–472.
Pagano, M., Thadden, E.V., 2004. The European bond markets under EMU. Oxford Review of Economic Policy 20, 531–554.
Phillips, P.C.B., Perron, P., 1988. Testing for a unit root in time series regression. Biometrika 75, 335–346.
Phylaktis, K., Ravazzolo, F., 2005. Stock market linkages in emerging markets: implications for international portfolio diversification. Journal of International Financial Markets, Institutions and Money 15, 91–106.
Rangvid, J., 2001. Increasing convergence among European stock markets? A recursive common stochastic trends analysis. Economics Letters 71, 383–389.
Richards, A.J., 1996. Comovements in national stock market returns: evidence of predictability, but not cointegration. Journal of Monetary Economics 36, 631–654.
Serletis, A., King, M., 1997. Common stochastic trends and convergence of European Union stock markets. Manchester School 65, 44–57.
Syriopoulos, T., 2006. Risk and return implications from investing in emerging European stock markets. Journal of International Financial Markets, Institutions and Money 16, 283–299.
Wilson, P., Okunev, J., 1996. Evidence of segmentation in domestic and international property markets. Journal of Property Finance 7, 78–97.
Wilson, P., Zurbruegg, R., 2001. Structural breaks, diversification and international real estate markets – some new evidence. Briefings in Real Estate Finance 1, 348–366.
Yang, J., Kolari, W., Zhu, G., 2005. European public real estate market integration. Applied Financial Economics 15, 895–905.
Yunus, N., 2009. Increasing convergence between us and international securitized property markets: evidence based on cointegration tests. Real Estate Economics 37, 383–411.