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Interactions between Real Estate and Equity Markets: an Investigation of Linkages in Developed and Emerging Countries

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Abstract
This study analyzes the long-run cointegration relationship between equity and real estate prices in 30 developed and emerging economies divided into four subpanels related to the income level and the financial market structure. We test for cointegration between equity and real estate prices using the pooled mean group estimator of the dynamic heterogeneous panel on the entire panel sample and on subpanels in order to isolate the variation of codependencies among country groups. The results suggest equity prices and real estate prices are closely correlated, synchronized and codependent, with the degree of codependencies depending on the income levels and the structure of the financial markets of the given countries. In economies with a market-based financial system and in developed economies, the reaction of both asset prices to economic news is more synchronized when compared to the remaining two groups. The stock market crash and the global financial crisis significantly increased the level of segmentation between the stock markets and the real estate markets, with the segmentation being more pronounced in developed economies.

1. Introduction

The relationship between real estate and stock returns is important to portfolio managers, investors and households. Portfolio managers and investors seek to optimize the returns from their portfolios by allocating resources across different asset classes such as real property, equities and fixed income. Therefore, it is assumed that assets in a portfolio are not close substitutes because in that case there would not be the risk reduction that investors and portfolio managers seek. On the other hand, with the development of financial markets in general, and housing equity withdrawal instruments in particular, households increasingly view property as an investment asset that can substitute for other types of savings such as stocks, mutual funds or even bank deposits. Therefore, the interaction of real estate markets and equity markets should be a matter of concern both to households and investors. If two markets share the same long-run trend (i.e. are cointegrated), then assets traded on those markets are closely substitutable and do not add to the diversification of a portfolio. A special case arises if the two asset prices are cointegrated, but the series are slowly mean reverting and exhibit a great deal of persistence. In such a situation any diversification benefit is restricted to the short to medium term. On the other hand, if the markets are segmented, then holding both assets in the same portfolio would enable investors and households to reduce risk by diversifying.

Real estate and equities are the two most important investment asset classes for most investors. They constitute the largest portions of wealth for both households

and businesses. That means real estate and equity prices determine both household consumption and business investment levels, thus influencing business cycle fluctuations and overall economic development. However, in this paper we do not intend to discuss the relationships between asset markets and the macroeconomy as implied under the asset pricing theory. Instead, we focus on examining the relationship between equities and real estate prices in order to discover a potential source of growth patterns for these assets. Therefore, our data set is composed of quarterly data for 30 countries from Europe, North America, the Middle East, Asia and Oceania. We divided the countries in the panel according to the level of national income and the dominant financing system, thus obtaining four subpanels: developed countries, emerging (developing) countries, countries with bank-based financial systems and countries with market-based financial systems. Emerging countries include eight countries from central and southeastern Europe (Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Lithuania, Russia and Slovenia) and Indonesia. Due to differences not only in overall income levels, but also in institutional frameworks and the development of the financial markets, one would expect significant differences in the properties of the long-term relationships between equities and real estate prices across these groups of countries. Moreover, due to the fact that the 2008 stock market crash was in largely caused by the bursting of the real estate bubble and financial sector losses in sub-prime mortgage markets, we also investigate whether this crash changed the relationship between the prices of equities and real estate.

The results suggest the level of codependence between equity price and real estate price movements is relatively high in all examined country groups. However, the degree of codependencies varies among country groups, with the reaction of both asset prices to economic news being more synchronized in economies with a market-based financial system and developed economies. The results also indicate that the 2008 global financial crisis significantly increased the level of segmentation between the stock markets and the real estate markets, with segmentation being more pronounced in developed economies.

This paper complements earlier studies examining the relationship between real estate and stock markets by offering a comprehensive analysis of the relationship between real estate and equity prices in 30 countries, both developed and emerging. By dividing the panel into four subpanels (developed countries, emerging countries, countries with bank-based financial systems and countries with market-based financial system); we explore the influence of the income level and the financial market structure on the variation of the relationship between real estate and equity prices. To the best of our knowledge, this is also the first paper to investigate the relationship between the real estate and equity markets in emerging countries, and the first one to compare the features of this relationship between developed and emerging countries. Moreover, due to the splitting of the sample into the periods before and after the stock market crash in 2008, we also provide an analysis of the effects of the global financial crisis on the relationship between the two markets.

To provide background for the study, Section 2 reviews the relevant literature. This is followed by a presentation of research data and methodology (Section 3 and 4). Section 5 provides the paper's findings and a discussion of the empirical results. The final section provides an overview of the study.

2. Literature Review

Studies examining the relationship between real estate and equity markets can be broadly divided into three categories. The first group of papers examines the properties of the long-term relationships between stock markets and real estate markets, usually within a cointegration framework. The second group of papers aims to empirically investigate the short-term features inherent in this relationship, while the third group seeks to uncover and identify nonlinearities in the relationship. Although numerous studies have explored the relationship between equity markets and real estate markets, there is still no consensus as to whether real estate and stock markets are integrated, probably due to differences in sampling areas and periods, data quality, and economic and institutional environments. In addition, so far the empirical studies have examined extensively the interaction between real estate and stock markets in developed countries, but as a rule have not looked into the interactions of these two markets in emerging countries. Most of the available empirical studies were published during the 1990s and in the early 2000s, before the last global stock market and real estate market boom-bust cycle took place. The 2008 stock market crash and the financial crisis that followed might have altered the main interaction channels between the two markets, thus diminishing the scope for their interdependencies.

Several earlier studies such as Geltner (1990); Liu et al. (1990); Wilson, Okunev and Ta (1996) and Quan and Titman (1999) document the existence of segmentation between various real estate markets and stock markets. The study conducted by Liu et al (1990), who use CAPM to examine the extent of the integration between commercial real estate markets and stock markets, suggest segmentation does exist as the result of indirect barriers such as the cost, amount and quality of information for real estate. Their findings are corroborated by Geltner (1990), who suggests that the two markets are segmented because the noise component of their returns is different. In a comprehensive study covering 17 countries, Quan and Titman (1999) report somewhat ambivalent results. When examining individual country cases, the authors find little evidence of integration. However, when the data is pooled and examined over a longer period, there is significant correlation between real estate and equity market returns, even after controlling for macroeconomic conditions. Wilson, Okunev and Ta (1996) apply the arbitrage pricing model to Australian data to test for a cointegration relationship between residential real estate and equity markets. Their results suggest that the cointegration relationship between these two markets is weak.

On the other hand, a growing body of evidence seems to support the notion that the two markets are indeed increasingly codependent and integrated. Several studies employing linear methods such as Miles et al. (1990), Gyourko and Kleim (1992), Lizieri and Satchell (1997a), Ling and Naranjo (1999), Tse (2001) and Anoruo and Braha (2008) confirm this finding. After examining the risk-return characteristics of commercial real estate series, Miles et al. (1990) conclude that they are consistent with risk-return characteristics that have been reported for equities, thus implying integration between those two markets. Lizieri and Satchell (1997a) use the Granger causality framework and detect a strong relationship between property returns and lagged values of equity returns in the UK. Ling and Naranjo (1999) employ the multifactor model and find that the market for traded real estate

companies is integrated with the stock market, with the degree of integration increasing during the 1990s. However, when using appraisal-based returns, the latter conclusion does not hold. Tse (2001) uses the vector error-correction framework on data for Hong Kong and reports that changes in residential and office property prices are important determinants of the change in equity prices. Anoruo and Braha (2008) conclude that residential real estate and stock markets in the United States are cointegrated. By applying GARCH-enhanced VECM, the authors find that stock markets adjust in the short run in order to correct long-run disequilibria.

All of the above-mentioned studies rely on the assumption that real estate and stock markets are linearly related. However, the linear models are misspecified if the true data generating process is non-linear. This in turn means that linear models may reject the hypothesis that stock markets and real estate markets are related if the underlying relationship is nonlinear. Nonlinear studies also do not provide a uniform conclusion, but the majority of those studies (such as Ambrose et al., 1992; Okunev and Wilson, 1997; Okunev, Wilson and Zurbruegg, 2000; and Liow and Yang, 2005) does seem to indicate that some level of integration between equity markets and real estate markets does exist.

Besides the aforementioned studies, a related strand of literature explores the influence of economic fundamentals on stock market and real estate returns. A growing body of evidence suggests that the variations in both stock and real estate returns are related to the state of the economy as reflected by the key macroeconomic variables. Examples of such key variables include real GDP, the discount rate, employment, inflation and the term structure of interest rates.

3. Research Data

Our data set is composed of the quarterly real estate price index, equity price index, real GDP and central banks' discount rates for 30 countries from Europe, North America, the Middle East, Asia and Oceania. We divided the countries in the panel according to the level of national income and the dominant financing system, thus obtaining four subpanels: developed countries, emerging (developing) countries, countries with bank-based financial systems and countries with market-based financial systems. Nine former socialist countries and countries with low and lower middle income according to the World Bank country classification are defined as emerging (developing) countries, while the remaining 21 countries are defined as developed countries. We used a classification developed in Levine (2002) in order to identify countries with bank-based and market-based financial systems. In our panel there are 17 countries with bank-based financial systems and 13 countries with market-based financial systems.

We used the longest possible data range for each country, thus forming an unbalanced panel. The longest data span, ranging from the first quarter of 1970 to the second quarter of 2012, is available for Finland, South Africa and the UK, while the shortest data span included in the panel is for Slovenia, with the data available from the first quarter of 2003 onwards. The data source for real estate price indices is the Property Price Statistics Database compiled by the Bank for International Settlement, while for equity prices we combined data available from Bloomberg, Eurostat and International Financial Statistics. As a source for real GDP and interest

rates series we used International the Financial Statistics and Eurostat databases. *Table A1 in the Appendix* summarizes all relevant information regarding subpanel division, data properties and sources for the 30 individual countries in our panel.

As far as the choice of variables is concerned, we use national stock market indices as a measure of equity market movements in the respective countries. Following the approach of Wilson, Okunev and Ta (1996), Tse (2001) and Anoruo and Braha (2008), we used residential real estate series instead of commercial real estate series (either actual or securitized). This enabled us not only to enlarge the data sample to 30 countries, but also to test for actual co-movement between equity and residential property prices. For five countries with available actual commercial property prices, we calculated the correlation coefficients between the first differences of commercial and residential real estate prices in order to verify whether residential prices could serve as a proxy for commercial real estate prices. In all five cases, correlation coefficients are quite high and significant at the 1% significance level.[1] In addition, He and Webb (2000) provide evidence on unidirectional causality from residential to commercial real estate prices and suggest residential and commercial real estate markets have similar responses to important economic and political news. Two additional macroeconomic control variables are included in the study (real GDP and discount rates) in order to check the robustness of the results. GDP is used as a proxy to measure the overall level of economic activity in the economy, while the discount rate proxies the expectations about future economic conditions and captures the state of investment opportunities. Where possible, we used central bank discount rates; in the remaining cases we used money market interest rates.

4. Research Methodology

In recent years, the literature on the dynamic panel data focused on unit root and co-integration properties of variables observed over a long time span and a large number of cross-section units, so-called "large T and large N case" (Pesaran et al., 1999). There is a huge resemblance between unit root tests carried out on a single series and a panel unit root test, but they are not identical. According to the literature, panel-based unit root tests have higher power than unit root tests based on individual time series. In this paper we use a battery of unit root tests, namely tests with common unit root processes: LLC (Levin et al., 2002), Breitung (Breitung, 2000), and Hadri (Hadri, 2000) and tests with individual unit root processes: IPS (Im et al., 2003) and Fisher ADF test (Maddala and Wu, 1999; Choi, 2001). Since we are interested in the long-run equilibrium relationship between stock markets and real estate markets which cannot be consistently estimated if all single variables have a unit root, unless they are co-integrated in the long run, the next step of our analysis is to perform panel co-integration tests. In panel settings there are several ways of testing the null hypothesis of no cointegration. Namely, these test are grouped in two large families: the residual-based ones (Pedroni, 1999 and 2004; Kao, 1999), constructed on the basis of the Engle and Granger's (1987) test and likelihood-based ones (Maddala and Wu, 1999) which represent the generalization of the Johansen (1991, 1996) test for vector autoregressive models to panel data. Also, we use four new panel cointegration tests developed by Westerlund (2007) that are based on

[1] For details, please refer to *Table A2 in the Appendix*.

the structural dynamic, as opposed to the residual dynamic used by the tests represented earlier. The main idea is to test the null hypothesis of no cointegration by inferring whether the error-correction term in the conditional panel error-correction model is equal to zero.

Since our analysis has shown that all the variables of interest have a unit root and are cointegrated in the long run, we use the following specification of the empirical model linking stock and real estate prices:

$$pprice_{it} = \gamma_{0i} + \gamma_{1i} eprice_{it} + \varepsilon_{it} \qquad i = 1,2,...,N, t = 1,2,...,T \tag{1}$$

Where *pprice* is the logarithm of the real estate price and *eprice* is the logarithm of the equity price. The error term capturing the effects of unexpected shocks to real estate prices is denoted by ε_{it}. The subscripts *i* and *t* denote the country and time respectively. Our model can be written as autoregressive distributed lag ARDL (1,1):

$$pprice_{it} = \delta_i + \beta_{10i} eprice_{it} + \beta_{11i} eprice_{i,t-1} + \gamma_i pprice_{i,t-1} + \eta_{it} \tag{2}$$

In the case of our model, the variables are I(1) and cointegrated, so the error term is an I(0) process for all countries (*i*). Because the cointegrated variables show great responsiveness to any deviation from long-run equilibrium, this feature implies an error-correction reparametrization such as:

$$\Delta pprice_{it} = \varphi_i \left(pprice_{i,t-1} - \gamma_{0i} - \gamma_{1i} eprice_{i,t-1} \right) - \beta_{11i} \Delta eprice_{it} + \eta_{it} \tag{3}$$

where:

$$\varphi_i = -\left(1-\gamma_i\right), \gamma_{0i} = \frac{\delta_i}{1-\gamma_i}, \gamma_{1i} = \frac{\beta_{10i} + \beta_{11i}}{1-\gamma_i} \tag{4}$$

Parameter φ_i is the error-correcting speed of adjustment term, so we expect it to be significantly negative under the prior assumption that the variables show a return to long-run equilibrium. The ARDL methodology has been used extensively in empirical studies of panel data related to both emerging and developed economies whenever panel data variables are non-stationary, and cointegration among variables is either suspected or suggested by the theoretical underpinnings. Common applications of the ARDL methodology include, among other things, personal consumption models, economic growth models and growth accounting, FDI and growth nexus, and finance and growth nexus.

Based on recent advances in the non-stationary panel literature in which both *N* and *T* are large, in this paper we use three alternative estimators: a traditional fixed-effect (FE) estimator, the mean-group (MG) estimator and pooled mean-group (PMG) estimator. The dynamic FE estimator (DFE), restricts the coefficients of the cointegrating vector to being equal across all panels. Also, it restricts the speed of adjustment coefficient and the short-run coefficients to being equal, so only the intercepts are allowed to differ across countries. Furthermore, using the MG estimator (Pesaran and Smith, 1995), the model will be fitted separately for each group and a simple average of the coefficients will be calculated, so that the intercepts, slope coefficients and error variances are allowed to differ across groups. Finally, we will use the PMG estimator (Pesaran et al., 1999) as the intermediate procedure between the former estimators, allowing the intercepts, short-run coefficients and error

Table 1 Panel Unit Root Tests Results

Test	Null hypothesis	Alternative hypothesis	*p*-values			
			Stock market index	Real estate index	GDP	Discount rate
Im-Pesaran--Shin	All panels contain unit roots.	Some panels are stationary.	0.43	1.00	0.99	0.99
Fischer	All panels contain unit roots.	At least one panel is stationary.	0.99	1.00	0.99	0.98
Levin-Lin-Chu	All panels contain unit roots.	All panels are stationary.	0.25	0.99	0.83	0.99
Breitung	All panels contain unit roots.	All panels are stationary.	0.13	0.72	0.98	0.99
Hadri	All panels are stationary.	Some panels contain unit roots.	0.00	0.00	0.00	0.00

Note: Levin-Lin-Chu, Breitung and Hadri tests require a balanced panel and were therefore applied to a truncated version of the dataset.

Source: Authors´ calculation.

variances to differ across groups, constraining the long-run coefficients to being equal across groups.

The Hausman test of long-run homogeneity of coefficients is employed to the whole panel and to the sub-panels to determine which of the proposed estimators is most appropriate for this setting. The MG estimator provides consistent estimates of the mean of long-run coefficients, but they will be inefficient under the slope homogeneity assumption. If indeed the long-run slope coefficients are homogeneous, the PMG and DFE estimators are consistent and efficient (Pesaran et al. 1999). Moreover, Baltagi et al. (2000) mention that DFE models are subject to a simultaneous equation bias arising from the endogeneity between the error term and the lagged dependent variable. Therefore, the Hausman test is also employed to measure the extent of this endogeneity.

5. Results

Table 1 summarizes the panel unit root tests for stock market and real estate price indices. Both types of tests (tests with common and with individual unit root processes) suggest the stock market index, real estate index and both macroeconomic control variables are non-stationary I(1) processes.[2]

Panel cointegration tests results displayed in *Table 2* indicate that stock markets and real estate markets are indeed cointegrated in the long run when the sample includes all 30 countries. Both residual-based and likelihood-based tests, as well as the Westerlund test, corroborate this conclusion. Cointegration between real estate and stock markets is also found when examining all four subpanels. The null hypothesis of no cointegration (or error-correction) is strongly rejected in most of the cases, with the exception of the subpanel of countries with bank-based financial systems, where the null hypothesis in the Pedroni and Kao tests are rejected at the 10% significance level.

[2] Unit root results for real estate and stock market indices in the cases of the four subpanels also suggest the series are I(1). These results are not presented in the paper due to space considerations, but they can be obtained from the authors upon request.

Table 2 Panel Cointegration Test Results: Equity Price and Real Estate Price

Test	Null hypothesis	Alternative hypothesis	Name of the statistics	*p*-values				
				All countries	Developed countries	Developing countries	Countries with bank-based financial system	Countries with market-based financial system
Westerlund	No EC	All panels contain EC.	Gt	0.00	0.00	0.00	0.00	0.00
			Ga	0.00	0.00	0.00	0.02	0.00
		Some panels contain EC.	Pt	0.00	0.00	0.00	0.00	0.00
			Pa	0.00	0.00	0.00	0.01	0.00
Pedroni	No cointegration	Homogenous cointegration	Panel ADF	0.01	0.02	0.00	0.06	0.06
		Heterogeneous cointegration	Group ADF	0.00	0.00	0.02	0.01	0.01
Kao	No cointegration	One cointegration relationship	Panel ADF	0.00	0.00	0.00	0.06	0.00
Johansen Fisher	No cointegration	At most one cointegration relationship	Fisher trace	0.00	0.00	0.00	0.00	0.00
			Fisher max	0.00	0.00	0.00	0.00	0.00

Source: Authors´ calculation.

Table 3 Baseline Model

	All countries	Developed countries	Developing countries	Countries with bank-based financial system	Countries with market-based financial system
Speed of adjustment φ_i	-0.036*** [0.007]	-0.021*** [0.004]	-0.069*** [0.021]	-0.056*** [0.013]	-0.019*** [0.003]
Long-run coefficients					
Equity price γ_{1i}	0.798*** [0.040]	1.040*** [0.082]	0.54*** [0.033]	0.542*** [0.030]	1.16*** [0.106]
Short-run coefficients					
Equity price $ß_{11i}$	0.056*** [0.01]	0.057*** [0.015]	0.046*** [0.013]	0.054*** [0.012]	0.050*** [0.018]
Long-run unit elasticity restriction	25.27 (0.00)	0.24 (0.623)	198.12 (0.00)	239.38 (0.00)	2.37 (0.124)
Number of observations	2677	2081	596	1135	1542
Number of countries	30	20	10	17	13
Log likelihood	8470.5	6802.0	1683.7	3333.8	5158.5
Hausman test PMG	0.83 (0.36)	0.70 (0.403)	0.12 (0.732)	0.34 (0.559)	0.69 (0.405)
Hausman test DFE	0.00 (0.958)	0.00 (0.964)	0.00 (0.958)	0.01 (0.937)	0.00 (0.996)

Notes: The estimations are performed using the PMG estimator of Pesaran et al. (1999); panel ARDL (1,1) model; the reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients; all equations include a constant term; standard errors are in brackets, *p*-values are in parentheses; *** denotes significance at the 1% confidence level; Hausman test PMG denotes a test for long-run homogeneity. Hausman test DFE denotes an endogeneity test.

Source: Authors´ calculation.

After confirming that stock markets and real estate markets are cointegrated in the main panel and all four subpanels, we proceed by estimating an error-correction model formulated by the Equation (3), using the PMG estimator. Along with estimating the short-run and the long-run parameters of the error-correction model, we also test the restriction that the long-run equity price parameter γ_{1i} is equal to one. If this restriction is accepted, it implies that in the long-run changes in stock markets are completely transmitted to real estate markets, and that the long-run movements of these two markets are highly synchronized and codependent. *Table 3* summarizes the main results for the thirty-country panel and four subpanels.

As evident from *Table 3*, all five models satisfy Hausman specification tests for long-run homogeneity and also suggest that simultaneous equation bias from the endogeneity between the error term and the lagged dependent variable is minimal. The long-run stock market coefficient in all five panels is highly statistically significant, and its estimate ranges from 0.54 in developing countries to 1.16 in countries with market-based financial systems, whereas in the main thirty-country panel it amounts to 0.798. This finding suggests integration between stock markets and real estate markets is a widely dispersed phenomenon; however, the degree of dispersion varies among country groups. Obviously, due to their more developed financial systems and emphasis on equity financing, developed countries and especially countries with market-based financial systems exhibit a higher degree of integration when compared to developing and countries with bank-based financial system (all 13 market-based countries in the sample are developed countries). The $\chi^2(1)$ test statistics and associate *p*-values suggest that the long-run stock market parameter can be restricted to 1 in the subpanel of developed countries and in the subpanel of countries with market-based financial systems. This indicates that stock markets and real estate markets in those two country groups are more completely integrated and highly synchronized. Moreover, contemporaneous linear long-term relationship suggests that the two markets respond in a similar manner to underlying economic conditions.

Adjustment coefficient estimates are correctly signed and are also very significant, albeit quite small. In the main panel, its estimate is -0.036, which implies a half-life of 14 quarters. This means that it takes 14 quarters for the deviations of the two markets to reduce to half of the initial divergence. The mean reversion is somewhat faster in emerging countries and countries with bank-based financial systems than in developed countries and countries with market-based financial systems, but since it is generally very low in all subpanels one may conclude that real estate prices exhibit a great deal of persistence. These findings corroborate the results obtained by Okunev and Wilson (1997), who also detected slow mean reversion accompanied by a high value of the half-life, albeit in a nonlinear framework.

As a robustness check, we added two macroeconomic controls (GDP and the discount rate) and provided another estimate of the main panel and four subpanels. The results are outlined in *Table 4*. The adjustment term is significant and correctly signed in all five models, suggesting that cointegration indeed exists.[3]

[3] Panel cointegration tests results for the model with two macroeconomic controls are not supplied due to space considerations, but are available from the authors upon request. They indicate that equity prices, real estate prices, real GDP and the discount rate are cointegrated in the main panel and all four subpanels.

Table 4 Robustness Check—Macroeconomic Controls

	All countries	Developed countries	Developing countries	Countries with bank-based financial system	Countries with market-based financial system
Speed of adjustment φ_i	-0.025*** [0.003]	-0.0175*** [0.003]	-0.046*** [0.009]	-0.034*** [0.007]	-0.017*** [0.003]
Long-run coefficients					
Equity price γ_{1i}	0.576*** [0.087]	0.713*** [0.145]	0.59*** [0.133]	0.588*** [0.147]	0.824*** [0.125]
GDP γ_{2i}	0.0715 [0.182]	-0.097 [0.274]	0.132 [0.268]	-0.644 [0.541]	0.236 [0.170]
Interest rate	-0.010*** [0.003]	-0.016*** [0.005]	-0.003 [0.006]	-0.002 [0.007]	-0.020*** [0.004]
Short-run coefficients					
Equity price $ß_{11i}$	0.035*** [0.006]	0.037*** [0.007]	0.024 [0.017]	0.017 [0.012]	0.027*** [0.006]
GDP $ß_{21i}$	0.619*** [0.052]	0.502*** [0.052]	0.872*** [0.139]	0.552*** [0.096]	0.637*** [0.045]
Interest rate $ß_{31i}$	-0.0002 [0.0003]	0.0003 [0.0003]	-0.002** [0.0008]	- 0.001 [0.0006]	0.0005** [0.0002]
Number of observations	2677	2081	596	1135	1542
Number of countries	30	20	10	17	13
Log likelihood	9530	8712.3	2122.3	3852.0	6241.3
Hausman test DFE	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (0.99)	0.69 (0.405)

Notes: The estimations are performed using the PMG estimator of Pesaran et al. (1999); panel ARDL (1,1,1,1) model; the reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients; all equations include a constant term; standard errors are in brackets, *p*-values are in parentheses; *** and ** denote significance at the 1% and 5% confidence levels, respectively. Hausman test DFE denotes an endogeneity test.

Source: Authors´ calculation.

The long-run equity price coefficient is still highly significant in all five models, but when compared to the baseline model its value is lower in the main panel, subpanel of developed countries, and in the subpanel of countries with market-based financial systems.

These results suggest that a part of the correlation between equity prices and real estate prices in developed countries and countries with market-based financial systems arises because of the common economic fundamentals affecting both markets. On the other hand, the long-run equity price coefficient estimate remained unchanged (and even increased by a small fraction) in developing countries and countries with bank-based financial systems, thus implying that the long-run asset price co-movements and corresponding integration of stock markets in real estate markets in those countries are not affected by underlying economic conditions. The long-run discount rate coefficient is significant in all panels, except in the panel of developing countries. As expected, in the long-run the reference rate changes have the greatest influence on real estate prices in countries with market-based financial systems. For countries with market-based financial systems, discount rates are also significant in the short run. Real GDP does not seem relevant for explaining long-run

real estate price changes, but it does affect real estate markets in the short run in all four subpanels, as well as in the main panel. The short-run GDP coefficient is significant at the 1% significance level and its estimate varies from 0.502 in developing countries to 0.872 in developed countries.[4]

We can conclude that the integration between real estate and the stock markets exists, and it seems to be a widespread phenomenon. The degree of integration obviously varies across countries depending on the level of their national income and financial market structures. Additionally, although long-run correlation between equity prices and real estate prices weakens somewhat after controlling for the changes in the macroeconomic factors in developed countries and countries with market-based financial systems, it is still quite high and very significant. This implies that in countries with market-based financial systems and developed countries a part of the correlation arises because of common economic news affecting markets, a finding that is also corroborated by Ling and Naranjo (1999), Quan and Titman (1999), and Liow (2006). On the other hand, the level of integration between the stock markets and the real estate markets in developed countries and countries with bank-based financial systems does not seem to depend on underlying economic conditions, which can be interpreted as a lack of a synchronized response of asset markets in these countries to changes in economic fundamentals.

Table 5 presents the estimates of the baseline model split into two subperiods. The first period ends with the second quarter of 2008, while the second period starts with the third quarter of 2008, thus incorporating the collapse of Lehman Brothers, the consequent world-wide stock market crash in September 2008, and the global economic crisis that followed. The results clearly demonstrate that the 2008 stock market crash and the global financial crisis heavily disrupted the synchronization that existed in these markets prior to the crash. The long-run stock market estimate from the main panel suggests a reduction from 1.028 recorded prior the crash to just 0.087 after the crash. If one analyses the subpanel results, it becomes obvious that the relationship between stock market and real estate prices broke down primarily because of the developments in developed countries and countries with market-based financial systems. In developed countries the long-run equity price coefficient shrank from 1.159 before the crisis to 0.079 after the crisis, while in countries with market-based financial systems it plunged from 1.39 to 0.50. As opposed to countries with market-based financial systems, the reduction in the degree of long-run codependence between equity prices and real estate prices in developing and economies with bank-based financial systems was not that substantial. This is probably due to the fact that in developed countries in general and in countries with market-based financial systems in particular, the tight long-run relationship between the two markets is reinforced by the introduction and development of various securitized real estate and mortgage-related products traded on the stock market. These financial products are underdeveloped (in some cases even nonexistent) in the emerging countries and countries with bank-based financial systems. Moreover, the emer-

[4] As an additional robustness check, we compare PMG and DFE estimates of the dynamic heterogeneous panel model specified by Equation 3 and conclude that the only major difference occurs in subpanel of countries with bank-based financial systems, where the long-run equity price coefficient is lower when compared to the baseline PMG estimate. The DFE estimates of the model are supplied in *Table 3A in the Appendix*.

Table 5 PMG Estimates, Before and After the Stock Market Crash in September 2008

	All countries – before the crash	All countries – after the crash	Developed countries – before the crash	Developed countries – after the crash	Developing countries – before the crash	Developing countries – after the crash	Countries with bank-based financial system – before the crash	Countries with bank-based financial system – after the crash	Countries with market-based financial system – before the crash	Countries with market-based financial system – after the crash
Speed of adjustment φ_i	-0.018*** [0.004]	-0.130** [0.053]	-0.016*** [0.003]	-0.10 [0.073]	-0.034 [0.024]	-0.11*** [0.035]	-0.033** [0.015]	-0.051 [0.043]	-0.016*** [0.003]	-0.042** [0.020]
Long-run coefficients										
Equity price γ_{1i}	1.028*** [0.087]	0.087*** [0.008]	1.159*** [0.125]	0.079*** [0.008]	0.680*** [0.037]	0.487*** [0.047]	0.653*** [0.032]	0.456*** [0.042]	1.39*** [0.19]	0.50*** [0.088]
Short-run coefficients										
Equity price $ß_{11i}$	0.041*** [0.011]	0.044*** [0.016]	0.043*** [0.015]	0.073*** [0.021]	0.031** [0.012]	0.030** [0.014]	0.037*** [0.012]	0.037*** [0.011]	0.039** [0.019]	0.096*** [0.026]
Number of observations	2214	463	1770	311	444	152	877	258	1337	205
Number of countries	30	30	20	20	10	10	17	17	13	13
Log likelihood	7158.517	1627.862	5887.715	1164.702	1277.669	483.475	2702.669	823.4468	4470.182	808.2929
Hausman test PMG	0.22 (0.640)	0.02 (0.899)	0.19 (0.661)	0.59 (0.965)	0.00 (0.980)	0.03 (0.871)	8.76 (0.271)	0.03 (0.985)	0.64 (0.423)	3.32 (0.189)
Hausman test DFE	0.00 (0.996)	0.20 (0.657)	0.00 (0.989)	0.00 (0.99)	0.03 (0.869)	0.00 (0.986)	0.00 (0.994)	0.00 (0.961)	0.00 (0.998)	0.00 (1.00)

Notes: The estimations are performed using the PMG estimator of Pesaran et al. (1999); panel ARDL (1,1) model; the reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients; all equations include a constant term; standard errors are in brackets; *** and ** denote significance at the 1% and 5% confidence levels, respectively; Hausman test PMG denotes the test for long-run homogeneity; Hausman test DFE denotes the endogeneity test.

Source: Authors´calculation.

Table 6 Speed of Adjustment Coefficients

Country	Baseline model	Country	Baseline model	Country	Baseline model
Austria	-0.0189 [0.01]	France	-0.0113** [0.005]	Norway	-0.021*** [0.007]
Australia	-0.018 [0.01]	Hong Kong	-0.044 [0.022]	Portugal	-0.0174*** [0.004]
Belgia	-0.0229*** [0.004]	Iceland	-0.013*** [0.004]	Russia	-0.132*** [0.029]
Bulgaria	-0.086*** [0.01]	Indonesia	-0.0004 [0.003]	Slovenia	-0.025 [0.016]
Canada	-0.0196*** [0.003]	Israel	-0.023** [0.009]	Spain	-0.063 [0.044]
Croatia	-0.00002 [0.00004]	Korea	-0.029*** [0.007]	Sweden	-0.0284*** [0.005]
Czech Republic	-0.031 [0.017]	Lithuania	-0.16*** [0.031]	South Africa	-0.013* [0.007]
Denmark	-0.073** [0.034]	Hungary	0.025** [0.010]	Switzerland	-0.011*** [0.003]
Estonia	-0.101** [0.044]	Netherlands	-0.032*** [0.004]	UK	-0.038*** [0.0064]
Finland	-0.008*** [0.003]	New Zeland	-0.021** [0.010]	USA	-0.0023 [0.004]

Notes: The estimations are performed using the PMG estimator of Pesaran et al. (1999); the standard errors are in brackets; ***, **, and * denote significance at 1%, 5% and 10% confidence levels, respectively.

Source: Authors´ calculation.

gence of real estate investment trusts, which in most cases has been limited to economies with market-based financial systems, adds another transmission channel trough which real estate markets and stock markets interact and get synchronized. The same can also be said for many real estate firms that are listed and actively traded on stock exchanges. Therefore, it should not come as a surprise that codependencies between real estate markets and stock markets in countries that rely predominantly on equity financing and developed economies are much more sensitive to the effects of the global financial crisis, which was triggered by the bursting of the real estate bubble and which brought about huge financial-sector losses associated with securitized mortgage products.

One also has to note that the error-correction term estimate after the 2008 stock market crash in all five models is much larger in comparison to the corresponding estimate before the crash. For example, in the main panel real estate prices corrected 1.8% of total deviations in one quarter before the crash, whereas after the crash the speed of adjustment accelerated 13% per quarter. Among country groups, the biggest increase in adjustment speed is recorded for developed countries. Obviously the financial crisis, coupled with deleveraging and elimination of asset prices bubbles, boosted the mean reversion process.

Since the PMG estimator places a homogeneity restriction on the countries' long-run coefficients while allowing the short-run coefficients to vary among countries, *Table 6* displays the estimates of the error-correction term from individual countries. One could claim that countries in which real estate and stock markets do not exhibit mean reversion, as suggested by the statistically insignificant error-correction term,

could also be considered as countries where the two markets are not integrated. Alternatively, the insignificant error-correction term could also be explained as an indication of real estate price persistence. Such a situation is present in nine countries: Austria, Australia, Croatia, the Czech Republic, Hong Kong, Indonesia, Slovenia, Spain and the United States. Since these countries belong to all four subpanels and are geographically spread across four continents, one cannot claim that the lack of mean reversion (and possibly integration) is due to geographical proximity, the level of national income or the financial market structure. Obviously, the discrepancies between asset prices in these countries are idiosyncratic and are probably related to some specific asset market features.

6. Concluding Remarks

This study provides evidence which support the notion that two types of asset prices—equity prices and real estate prices—are closely correlated, synchronized and codependent in the long-run. The level of long-run codependence hinges on the levels of national incomes and the structure of financial markets. Developed countries in which equity financing is more dominant than credit financing exhibit a greater degree of codependence, which can be attributed to the existence of various real estate sector-related financial products that are actively traded on stock exchanges, thus indirectly bringing two markets onto the same trading platform. Such financial products may vary from securitized real estate and mortgage products to stocks of real estate companies and REIT stocks.

The analysis performed in this paper also showed that due to the importance of various financial instruments related to mortgages and real estate, stock markets and real estate markets in market-based and developed economies are also much more synchronized when reacting to news about economic fundamentals. In addition to these factors, stock and real estate prices may also move together if business cycle variables simultaneously affect corporate profits and rents, or if the expectations of future profits and rents are closely related. Naturally, the long-run relationship of equity prices and real estate prices in developed countries and countries with market-based financial systems also proved to be much more sensitive to the 2008 stock market crash, which was triggered by the real estate bubble bursting and huge losses of financial institutions related to securitized mortgage products.

On the other hand, the relationship between equity prices and real estate prices seems to be much more stable in developing countries and countries with bank-based financial systems. Although the overall level of the long-run correlation of stock market prices and real estate prices is much lower in these countries when compared to developed countries and countries with market-based financial systems, this level remains unchanged when one introduces macroeconomic controls into the model, suggesting that these markets differ somewhat in response to economic news. Moreover, the magnitude of the global financial crisis's impact on the stock market—real estate market relationship in developing countries and countries with bank-based financial systems is much more moderate when compared to the other two country groups, probably due to the fact that they generally lack an interaction channels (in terms of various real estate sector-related financial instruments) and have consequently been much less exposed to losses related to securitized mortgage assets.

Estimates of the error-correction terms suggest that the mean reversion is very slow, probably due to real estate price persistence. The mean reversion process, however, speeded up greatly after the stock market crash, suggesting that in recent years both markets are working their way back to the equilibrium levels.

There are several ways in which the analysis in this paper could be improved. Firstly, one can try to endogenise the income levels and the structure of the financial markets of the individual countries. Secondly, the PMG estimator of the dynamic heterogeneous panel model suggests a linear relationship exists between equity prices and real estate prices. Although we are able to reject the null hypothesis of no cointegration, which should be more difficult if the true data generating process is indeed nonlinear, this does not mean that it would not be useful and informative to apply a nonlinear technique in order to capture the interactions between these two markets when we know that asset prices tend to exhibit nonlinear behavior (Liu and Su, 2010; Lizieri et al., 1998; Narayan, 2005; Posedel and Vizek, 2011; Shively, 2003). Lastly, we are well aware of the limitations stemming from the use of residential real estate prices as a proxy for commercial real estate prices. Although these two asset classes are usually highly correlated and subject to the same systemic factors, some divergence between the two series undoubtedly arises, especially in the short run. This in turn means that any recommendation regarding the composition of an optimal portfolio based on this analysis should be made with due caution. The use of residential prices in this analysis could, however, also be considered an advantage. Namely, due to increased securitization of residential real estate products in the last two decades, it makes perfect sense to investigate interdependencies between equity prices and residential real estate prices. Indeed, the results presented in this study suggest not only that these two asset prices are highly synchronized and interrelated, but also that equity prices can be considered a source of growth for real estate prices, regardless of the given country's financial structure, income level and the time period under examination.

Appendix

Table A1 Data Description, Data Sources and Country Divisions

Country	Subpanels	Data range	Real estate price	Equity price	GDP	Interest rate
Austria	Developed, bank-based	1986Q3–2012Q1	All types of dwellings, new and existing, BIS	Austrian Traded Index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Australia	Developed, market-based	1986Q3–2012Q1	All types of dwellings, existing, big cities, BIS	AS51 Index, Blomberg	GDP, real, IFS	Discount Rate, IFS
Belgium	Developed, market-based	1973Q3–2012Q2	All types of dwellings, existing, BIS	Belgian 20 Price Index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Bulgaria	Developing, bank-based	2000Q4–2012Q2	Flats, existing, big cities, BIS	Sofia Stock Exchange index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Canada	Developed, market-based	1981Q1–2012Q2	Single-family houses, new and existing, BIS	SPTSX Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
Croatia	Developing, bank-based	1998Q1–2012Q1	All types of dwellings, new and existing, Croatian National Bank	Crobexindex, Bloomberg	GDP, real, IFS	Money Market Rate, Eurostat
Czech Republic	Developing, bank-based	1998Q1–2012Q1	Single family houses and flats, BIS	Prague Stock Exchange 50 Index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Denmark	Developed, bank-based	1992Q1–2012Q2	Single family houses and flats, new and existing, BIS	KøbenhavnsFondsbørsIndex, Eurostat	GDP, real, IFS	Discount Rate, IFS
Estonia	Developing, bank-based	1997Q1–2012Q1	All types of dwellings, new and existing, BIS	Tallinn Stock Exchange index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Finland	Developed, bank-based	1970Q1–2012Q1	All types of dwellings, new and existing, BIS	Helsinki Stock Exchange All-Share Index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
France	Developed, bank-based	1996Q1–2012Q2	All types of dwellings, existing, BIS	Compagnie des Agents de Change 40 Index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Hong Kong	Developed, market-based	1996Q1–2012Q2	All types of dwellings, BIS	HSI Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
Hungary	Developing, bank-based	2001Q4–2012Q2	All types of dwellings, existing, BIS	Budapest Stock index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Iceland	Developed, bank-based	2000Q1–2012Q1	All types of dwellings, new and existing, BIS	ICEXI15 Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS

Country	Subpanels	Data range	Real estate price	Equity price	GDP	Interest rate
Indonesia	Developing, bank-based	2002Q1–2012Q1	All types of dwellings, new, BIS	JCI Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
Israel	Developed, market-based	2001Q1–2012Q2	All types of dwellings, new and existing, BIS	TA-25 Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
Korea	Developed, market-based	1986Q1–2012Q2	All types of dwellings, new and existing, BIS	KOSPI Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
Lithuania	Developing, bank-based	2000Q1–2012Q2	All types of dwellings, new and existing, BIS	Vilnius Stock Exchange Index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Netherlands	Developed, market-based	1977Q1–2011Q4	All types of dwellings, existing, BIS	Amsterdam Exchanges index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
New Zeland	Developed, market-based	1982Q2–2012Q2	All types of dwellings, new and existing, BIS	Share price index, IFS	GDP, real, IFS	Discount Rate, IFS
Norway	Developed, bank-based	1992Q1–2012Q2	All types of dwellings, new and existing, BIS	Oslo Bors All-Share Index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Portugal	Developed, bank-based	1988Q1–2011Q4	All types of dwellings, new and existing, BIS	Portuguese Stock Index 20, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Russia	Developing, bank-based	2001Q1–2012Q1	All types of dwellings, existing, BIS	INDEXCF Index, Bloomberg, Eurostat	GDP, real, IFS	Discount Rate, IFS
Slovenia	Developing, bank-based	2003Q1–2011Q4	All types of dwellings, new and existing, BIS	SlovenskiBorzniIndex	GDP, real, IFS	Discount Rate, IFS
South Africa	Developed, market-based	1970Q1–2012Q2	Single-family houses, new and existing, BIS	Share price index, IFS	GDP, real, IFS	Discount Rate, IFS
Spain	Developed, bank-based	1995Q1–2012Q1	All types of dwellings, new and existing, BIS	Association of Stock Exchanges Index, Eurostat	GDP, real, IFS	Official lending rate, Eurostat
Sweden	Developed, market-based	1986Q1–2012Q2	All types of dwellings, new and existing, BIS	OMX Stockholm 30 Index, Eurostat	GDP, real, IFS	Discount Rate, IFS
Switzerland	Developed, market-based	1988Q3–2012Q2	Single-family houses and flats, new and existing, BIS	SMI Index, Bloomberg	GDP, real, IFS	Discount Rate, IFS
UK	Developed, market-based	1970Q1–2012Q2	All types of dwellings, new and existing, BIS	FTSE MIB Index, Eurostat	GDP, real, IFS	Discount Rate, IFS
USA	Developed, market-based	1975Q4–2012Q2	All types of dwellings, existing, BIS	Dow Jones Industrial Index, Eurostat	GDP, real, IFS	Discount Rate, IFS

Table A2 Correlation Coefficients between Residential and Commercial Real Estate Prices

	Denmark	Hong Kong	New Zealand	Switzerland	USA
Levels	0.93*	0.92*	0.97*	0.91*	0.93*
Annual growth rates	0.41*	0.82*	0.74*	0.54*	0.65*

Note: * significant at 1 percent confidence level

Source: Authors´calculation

Table A3 Robustness Check of the Baseline Model—Dynamic Fixed Effect Estimator

	All countries	Developed countries	Developing countries	Countries with bank-based financial system	Countries with market-based financial system
Speed of adjustment Φ_i	–0.028*** [0.005]	–0.020*** [0.003]	–0.055*** [0.023]	–0.047*** [0.009]	–0.017*** [0.194]
Long-run coefficients					
Equity price γ_{1i}	0.634*** [0.102]	0.736*** [0.135]	0.638*** [0.121]	0.412*** [0.062]	1.11*** [0.194]
Short-run coefficients					
Equity price $ß_{11i}$	0.058*** [0.008]	0.055*** [0.012]	0.066*** [0.009]	0.058*** [0.008]	0.052*** [0.017]
Number of observations	2677	2081	596	1135	1542
Number of countries	30	20	10	17	13

Notes: The estimates are performed using the PMG estimator of Pesaran et al. (1999); panel ARDL (1,1) model; the reported short-run coefficients and the speed of adjustment are simple averages of the country-specific coefficients; all equations include a constant term; standard errors are in brackets; *** denote significance at 1 percent confidence level.

Source: Authors´calculation

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