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Working Paper

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Centre for European
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An Assessment of the Relationship Between Public Real Estate Markets and Stock Markets at the Local, Regional, and Global Levels

Kim Hiang Liow and Felix Schindler

Non-technical Summary

The primary contribution of this study is to assess whether public real estate markets and stock markets are linked at the local, regional, and global levels, and to assess the evolution of their dynamic relationship and gradual integration during the last two decades for a comprehensive sample of nine public real estate and stock markets across Asia-Pacific, Europe, and the US.

For individual pairs of public real estate and stock markets, the analysis indicates that the current levels of local, regional, and global real estate and stock market correlations are time-varying and are, at most, moderate at the respective integration levels. The linkages between real estate and local stock markets in the Asia-Pacific economies are (significantly) higher than the corresponding regional and global linkages, while the non-Asia-Pacific public real estate markets are generally more correlated with the regional stock markets than with their respective local stock markets. Also, real estate and stock markets become more correlated in periods of high volatility, as the (recent) global financial crisis has indicated for all markets and the Asian crisis in 1997 and 1998 for the Asian markets, in particular. Causality analysis reveals that there are instances of contemporaneous and lead-lag interactions in return and volatility between real estate and stock markets; however, the causality relationship appears weaker. Further, the mean and variance causality linkages between the real estate and stock markets are found to be unstable over the "pre-crisis" and "crisis / post-crisis" periods. Finally, integration analysis implies that the real estate markets have, on average, slowly become more integrated with the regional and global stock markets, and, in the long run, less so with the local stock market.

By examining the relationship between real estate and stock markets for the nine economies as a group, we obtain the general co-movement between real estate and stock markets in a more direct way. For the three groups including nine public real estate markets, nine local stock markets and three regional stock markets, we are able to extract five common factors that generate returns – namely two real estate factors, two local stock market factors and one regional stock market factor. The nature of the factor structure not only allows us to associate two (real estate and local stock markets) factors fairly clearly to two groups (Asia and non-Asia); these extracted factors also allow us to directly assess the dynamic relationships between public real estate and stock markets as a group, and thereby complement the individual results. In addition, there appears to be a declining real estate and stock return dispersion and differential at the local, regional, and global levels for all nine economies, indicating a tendency of return convergence between real estate and stock markets in an international environment. Finally, our analysis serves to remind international investors being keen to developed real estate equities and common stocks in their portfolios of the changing portfolio diversification benefits of their real estate assets with local, regional, and global stocks.

Das Wichtigste in Kürze

Der zentrale Untersuchungsgegenstand dieses Aufsatzes liegt in der Analyse des Zusammenhangs zwischen den verbrieften Immobilien- und den Aktienmärkten auf nationaler, regionaler und globaler Ebene. Dabei werden die Entwicklung der zeitlichen Dynamik des Zusammenhangs und der Verlauf des Integrationsprozesses über die letzten beiden Dekaden für neun verbriefte Immobilien- und Aktienmärkte im asiatisch-pazifischen Raum, in Europa und in den USA betrachtet.

Die Ergebnisse der paarweisen Betrachtung von verbrieften Immobilien- und Aktienmärkten deuten darauf hin, dass die Korrelationen zwischen den beiden Märkten auf nationaler, regionaler und globaler Ebene zeitlichen Schwankungen unterliegen und dass das Integrationsniveau lediglich moderat ausfällt. Während die Zusammenhänge für die asiatisch-pazifischen Märkte auf nationaler Ebene signifikant stärker ausgeprägt sind, weisen die übrigen verbrieften Immobilienmärkte zu den regionalen Aktienmärkten höhere Korrelationen auf. Allgemein ist festzustellen, dass die Zusammenhänge zwischen beiden Märkten in Marktphasen hoher Volatilität deutlich ansteigen, wie die gegenwärtige internationale Finanzmarktkrise und die Asienkrise von 1997 und 1998 zeigen. Des Weiteren gibt es zwar Anzeichen dafür, dass sowohl bei den Renditen als auch in den Volatilitäten zeitliche Abhängigkeiten zwischen den verbrieften Immobilien- und Aktienmärkten existieren, allerdings sind die kausalen Zusammenhänge nur schwach ausgeprägt und sie erweisen sich bei einem Vergleich des Zeitraumes vor der globalen Finanzmarktkrise mit der Phase danach als zeitlich instabil. Abschließend zeigt sich, dass die Integration der verbrieften Immobilienmärkte langfristig gegenüber den regionalen und globalen Aktienmärkten leicht zunimmt, während die Integration mit den nationalen Aktienmärkten eher abnimmt.

Durch die gruppenweise Betrachtung der Immobilien- und Aktienmärkte der neun untersuchten Volkswirtschaften wird in einem weiteren Schritt ein besserer Einblick in den allgemeinen Zusammenhang zwischen beiden Assetklassen gewonnen. Insgesamt können auf Basis von drei Gruppen (neun nationale verbriefte Immobilienmärkte, neun nationale Aktienmärkte und drei regionale Aktienmärkte) fünf gemeinsame Faktoren extrahiert werden – zwei Immobilienmarkt-spezifische und zwei Aktienmarkt-spezifische Faktoren sowie ein regionaler Faktor. Dabei kann von den Immobilienmarkt- und Aktienmarkt-Faktoren jeweils einer den asiatischen und einer den nicht-asiatischen Märkten zugeordnet werden. Die gruppenbasierte Analyse ergänzt somit die Ergebnisse der länderspezifischen Betrachtung. Des Weiteren ist sowohl auf nationaler als auch auf regionaler und globaler Ebene ein Rückgang in den Renditeunterschieden zwischen den verbrieften Immobilien- und Aktienmärkten zu erkennen, was auf eine zunehmende Konvergenz beider Märkte hindeutet. Die Analyse weist international ausgerichtete Anleger, die in verbriefte Immobilienanlagen und Aktien investiert sind, auf das sich im Zeitablauf ändernde Diversifikationspotential von Immobilienanlagen gegenüber den nationalen, regionalen und globalen Aktienmärkten hin.

An Assessment of the Relationship between Public Real Estate Markets and Stock Markets at the Local, Regional, and Global Levels

Kim Hiang Liow* and Felix Schindler†

September 2011

Abstract

The primary contribution of this study is to assess whether public real estate markets and stock markets are linked at the local, regional, and global levels, and to assess the evolution of their dynamic relationship and gradual integration during the last two decades. For individual pairs of real estate and stock markets, our analysis shows that the current levels of local, regional, and global correlation between real estate and stock markets are time-varying and are, at most, moderate at the respective integration levels. The real estate and stock markets are both contemporaneously and causally linked in their returns and volatilities; however the causality relationship appears weaker. In the long run, the real estate markets have slowly become more integrated with the global and regional stock markets; while less integrated with the local stock markets. In addition, the extracted common factors allow for a direct assessment of the dynamic relationships between the real estate and stock markets as a group, and thereby complement the individual results. Finally, there appears to be a declining real estate and stock return dispersion and differential at the local, regional, and global levels for all nine economies, indicating a tendency of return convergence between real estate and stock market in an international environment.

Keywords: Time-Varying Integration, Return and Volatility Causality, Multivariate Asymmetric DCC-GARCH, Return Convergence, Securitized Real Estate Markets, International Stock Markets

JEL Classifications: C32, G31

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1 Introduction

In many economies, real estate investors can choose between private real estate (direct property investment) and public real estate (listed / securitized property investment). This study is concerned with public real estate which comprises listed property companies, listed real estate operating companies (REOCs) and listed real estate investment trusts (REITs). Because of strong growth in the global securitized real estate markets over the past decade (RREEF, 2007), public real estate (which represents partial and indirect ownership interest in the underlying real estate assets) has been considered as an essential asset class that deserves some allocation in mixed-asset portfolios and is often considered as suitable portfolio diversifier (Idzorek et al., 2006).

For public real estate investors, their underlying assets (i.e. real estate) in which they invest are transacted in the private real estate markets; however their shares are traded in the stock markets. Consequently it is expected public real estate markets would have a higher volatility than the direct real estate market which is in line with the broader stock market. Moreover, some developed public real estate markets have higher correlations with the regional or / and global stock markets because they are able to attract regional and international investors to their real estate equity and debt investment instruments, in an era of increasing globalization and real estate securitization in many developed financial markets, particularly since the 1990's when securitized real estate investment has become an increasingly important property investment vehicle in Asia-Pacific, Europe and the US. One important implication arising from this higher linkage between real estate markets and stock markets is that the differential risk premium will eventually disappear and that there will not be any potential for cross-asset and cross-border diversification for global investors and country funds. Higher interdependence between real estate markets and stock markets might also imply more or faster transmission of a crisis, indicating that there is now less opportunity for spreading risk, at least across the major developed public real estate and stock markets, than it was the case in the previous decade. A strong linkage between local real estate markets and local stock markets – for small locally oriented stock markets in particular – could also be driven by the fact that most real estate companies are invested domestically only and thus are much more vulnerable to domestic economic shocks. However, given the increasing economic integration the domestic economy and stock markets are more and more connected to international markets which might also cause spillovers to the direct real estate market.

There has been extensive academic research considering integration across national stock markets; similarly there has been increasing attention paid to the nature and evolution of international public real estate market integration over the last decade; however, less formal attention has been devoted to the examination of the nature and extent of relationship across public real estate and local, regional and global stock markets. This relative neglect is inconsistent with the recognition that global stock market integration might also lead to greater interdependence between real estate and stock markets. In addition, with growing economic importance of the Asia–Pacific region in recent years, greater integration between real estate and stock markets can be anticipated at the local, regional and global levels. Thus, a better understanding of the nature of the relationship between public real estate and stock markets at the local, regional and global levels, as well as their evolution in the relationship over time, are important for diversification across real estate and stock markets. With real estate as a major capital asset that contributes to both investors' diversification and wealth creation in the world economy, this is where our study intends to contribute.

The core objective of this paper is thus to investigate the empirical relationship between public real estate markets and stock markets at the local, regional and global levels from the co-movement, causality, dynamic integration and return convergence perspectives. With a sample of nine major public real estate markets over the last two decades, we first compare the time-varying conditional correlation (i.e. co-movement) for each pair of real estate market and stock market at the three levels, as well as assess the extent of conditional correlation evolution over time. Second, we explore the issue of cross-asset market causality in return and volatility. The examination of causation in mean using Granger causality test has commonly appeared in studies relating to financial market movements. On the contrary, the issue of variance causality has received less attention in international finance. Third, we address the dynamic nature of the integration between real estate markets and stock markets with three benchmark portfolios: local stock market, regional stock market and global stock market via a three-index model. Fourth, we repeat the analysis of the relationship between real estate and stock markets for the nine economies as a group using factor analysis. This group analysis complements the individual results and hopefully captures changes in the general real estate and stock market relationship of the world's nine major public real estate markets. Throughout the analysis, we also provide additional insights into the effects of the recent Global Financial Crisis (GFC) on the identified cross real estate and stock market relationship. Finally, we use the cross-asset market return dispersion approach to assess if higher return convergence exists between the real estate and stock markets as a group. The outcomes of various investigations on the individual pairs of real estate markets and the corresponding stock markets, as well as on the group basis hopefully improve investors' understanding regarding the dynamic relationship between public real estate and local, regional and global stock markets, as well as their changes over time and across regions. In this way, the contribution of the study is expected to be enhanced.

To our knowledge, no study has considered the three types of integration between real estate and stock markets together with the notable exception of Liow (2011) (see also literature review below). Nevertheless, the current paper can be differentiated from Liow (2011) in several aspects. We use an international sample that includes a broader set of markets (from Asia-Pacific, Europe and North America) over an extended period of more than 20 years. The varied sample and longer span of data used in this study provide more useful information in evaluating both short-term and long-run relationships between the real estate and stock markets concerned over time, across three geographical continents, as well as in an international environment. In addition to the time-varying conditional correlation perspective as in Liow (2011), we also assess the real estate and stock market relationship from the spillover, causality, integration and return convergence perspectives for the nine public real estate markets on an individual basis, as well as a group.

Our analysis leads to substantial conclusions. First, the current levels of local, regional and global real estate and stock market correlations for individual pairs of asset markets are time-varying and are at most moderate at the respective integration levels. The average real estate and local stock market correlations in the Asian economies are (significantly) higher than the corresponding regional and global correlations; in contrast the non-Asian public real estate markets are generally more correlated with the regional stock markets than their respective local stock markets. Second, the real estate and stock markets are both contemporaneously and causally linked in their returns and volatilities; however the causality relationship appears weaker than its contemporaneous relationship. Third, the real estate markets have, on average, slowly become more integrated with the global and regional stock markets; while less integrated with the local stock market in the long-run. Fourth, for the nine real estate and stock markets as a group, we are able to summarize the information contained in the respective groups into up to two common factors. These extracted factors allow us to incorporate the dynamic conditional correlation, causality-in-variance and recursive integration score to assess directly the dynamic relationships between real estate and stock markets as a group, and thereby complements the individual results. Finally, the falling real estate-stock return dispersion and differentials at the local, regional and global levels indicate a tendency of return convergence between real estate and stock market in international investing.

This paper is organized as follows. Section 2 provides a brief review of relevant literature while Section 3 explains the different methodologies: dynamic conditional correlation (DCC), causality-in-mean and causality-in-variance (CIM and CIV), time-varying integration scores, principal component analysis (PCA), as well as return convergence approach. Section 4 describes the data sample and characteristics. The individual and group results as well as the combined implications are discussed in Section 5, with Section 6 concludes the study.

2 Relevant Literature

This study is related to several strands of literature in international investing. Our main objective to provide a comprehensive perspective regarding the interactions between real estate and stock markets at the local, regional and global levels. A search of the literature reveals that although numerous research studies have been devoted to the relationship between real estate and local stock markets, the conclusions from the prior research are mixed. On the one hand, research studies such as Zeckhauser and Silverman (1983), Brueggeman et al. (1984), Liu and Mei (1992), Gyourko and Keim (1992), Li and Wang (1995) and Ling and Naranjo (1999) have found that the two asset markets are connected. Gordon and Canter (1999) have examined the cross-sectional and time series differences in correlation coefficients between property stocks and their broader equity indices in 14 countries. Their results have provided evidence that the correlation coefficients tend to vary over time and there is a clear trend toward integration or segmentation of the real estate securities markets with the local stock markets in several of the countries studied. In contrast, other studies such as Ibbotson and Siegel (1984), Geltner (1990) and Ross and Zisler (1991) have argued that the two asset markets are largely segmented and consequently little relationship exists between them.

The closest study to our research is that of Liow (2011) who has examined the correlation relationship between real estate and stock markets at the local, regional and global levels for eight Asia-Pacific public real estate markets (Japan, Hong Kong, Singapore, Australia, China, Malaysia, Taiwan and Philippines) from 1995 to 2009. The author finds that the average correlation between real estate and local stock markets in all eight economies are significantly higher than the corresponding regional and global correlations. This higher correlation between real estate and local stocks can be attributed to the fact that property is a major asset component of many Asian economies and property companies mainly invest in their domestic market. Consequently, integration between real estate and the corresponding stock market has evolved largely at the local level in Asian public real estate markets. Moreover, this results indicate that the global and regional stock markets are able to influence national real estate returns differently, in addition to the country factors (i.e. local stock market). In contrast to Liow (2011), this study extends the current literature on the relationship between real estate and stock markets from the correlation, causality, integration and return convergence viewpoints from an international, rather than a pure Asian perspective.

In consistency with the literature, the ex-ante expectation is that increased real estate and stock market integration should be reflected in increased co-movements (correlations) between different real estate and stock market returns (Bracker and Koch, 1999). Since correlation changes over time (Longin and Solnik, 1995), time-varying conditional correlation measure is adequate to assess the return co-movement between real estate and stock markets. Methodologically, an increasing number of stock and real estate market studies have adopted the DCC methodology from the multivariate GARCH model proposed by Engle (2002). Essentially, the DCC-GARCH demonstrates a more direct indication of evolution of real estate and stock market correlation which is time-dependent and is modelled together with those of the volatility of the returns. It can be estimated with two-stage procedures based on a likelihood function (Yang, 2005; Wang and Moore, 2008). The DCC approach has the flexibility of a univariate GARCH. As the parameters to be estimated in the correlation process are independent of the number of the series to be correlated, a large number of series can be considered in a single estimation.

Second, causality tests and results provide investors with additional insights into how and when information is impacted on real estate market and stock market, as well as design more objective pricing models with appropriate lag structure. We use the CIV methodology developed by Cheung and Ng (1996) to uncover causal relations in returns and return volatilities with regard to the direction of causality as well as the number of leads and lags involved. While the issue of CIV has been investigated in some stock market studies (Hu et al., 1997; Tay and Zhu, 2000; Caporale et al., 2002 and Fujii, 2005), as well as in financial markets (Kanas and Kouretas, 2002 and Alangar and Bhar, 2003), we are not aware of any real estate study that has examined the CIV issue in the literature.

A third strand to search for a possible relationship between real estate and stock markets can be termed as the recursive integration score approach. Akdogan (1996) uses a risk-decomposition model to measure integration across world capital market. The model is subsequently extended by Akdogan (1997) and Barari (2004) to consider two-benchmark portfolios: local market and world market. In the real estate arena, Liow (2010) extends this methodology to consider a three-index model that includes a global stock market factor, a residual global real estate factor and a residual local stock market factor. Our study considers an alternative set of three benchmark portfolios: global stock market, regional stock market and local stock market to jointly evaluate real estate and stock market's time-varying historical integration scores at the local, regional and global levels.

Fourth, the use of factor analysis to reduce the larger group of original variables to a smaller group has been quite popular in the literature. For example, one of the earliest studies conducted by Ripley (1973) who employs factor analysis to search for systematic variation patterns among 19 international equity markets over the period from 1960 to 1970. Recent studies have included Asia-Pacific where Hui and Kwan (1994) and Hui (2005) investigate the systematic co-variation and inter-temporal stability of share prices for Asia-Pacific and US stock prices using factor analysis. Tuluca and Zwick (2001) use factor analysis to examine the co-movement for their sample of 13 Asian and non-Asian stock markets as a group. Fernandez-Izquierdo and Lafuente (2004) first use factor analysis to summarize the information contained in 12 stock markets into three latent factors. These three factors are associated to America, Asia and Europe. They then estimate a bivariate GJR-GARCH developed by Glosten et al. (1993, GJR) to analyse the volatility transmission between these three regions. In the real estate arena, Liow and Webb (2009) investigate the presence of common factors in the securitized real estate markets of the United States, the United Kingdom, Hong Kong, and Singapore using factor analysis. Their results have provided evidence that more common risk factors exist among real estate securities within a country than across countries. Moreover, there is at least one common securitized real estate market factor that is moderately correlated with the world real estate market, and to a lesser extent, with the world stock market.

Finally, as an alternative to the time series approach to estimating the level of integration of stock markets, Solnik and Roulet (2000) appeal to the cross-market return dispersion approach to assess the degree of stock market integration. This approach is simple and intuitive based on the law of one price. If the cross-market return dispersion reveals that there is a large discrepancy in equity market return across economies, it will imply that the equity markets do not display return convergence, and accordingly, the markets are not fully integrated.

3 Methodology

We investigate the nature and evolution of the relationship between real estate and stock markets for the individual market pairs, as well as a group using four approaches. For individual pairs of real estate and stock markets, we include a DCC analysis to capture the nature and evolution of the time-varying co-movements at the local, regional, and global levels. Second, the conditional standard residual estimates from the DCC model will be used to test the hypothesis that CIM and CIV exist between real estate and stock markets. A recursive integration score analysis will also be implemented to assess the dynamic nature of the long-term equilibrium relationship between the respective real estate and stock market pairs. For the nine economies as a group, the common factors derived from the PCA are used to investigate the return co-movement, mean and variance causality, long-run integration, as well as return convergence. The methodologies are described below in more details.

3.1 Dynamic Conditional Correlation Analysis

The most popular measure of the short-term relationship between the real estate and stock markets is the correlation coefficient. Since the correlation between real estate and stock markets might be time-varying, we appeal to the DCC methodology of Engle (2002) to model multivariate GARCH dynamic conditional correlation between the real estate and the local, regional, and global stock markets simultaneously for the nine economies. Since the conditional variance is an asymmetric function of past innovations, which increases proportionately more during market declines, we will use the DCC model and the asymmetric specification following Glosten et al. (1993) (i.e. the GJR-DCC model) to estimate the time-varying conditional correlations between the real estate markets and stock markets.

A two-step procedure is involved in the estimation of our AR (1)-GJR-GARCH (1, 1) model. A univariate GARCH model is first estimated for each time series. The transformed residuals from the first stage are then used to obtain a conditional correlation estimator in the second stage, with the correlation structure given as:

$$r_t = Q_t^{-1} Q_t Q_t^{-1} \text{ and}$$

the DCC covariance structure is specified by a GARCH process:

$$Q_t = (1 - \text{alpha} - \text{beta}) \cdot \bar{Q} + \text{alpha} \cdot (\eta_{t-1}\eta_{t-1}^{'}) + \text{beta} \cdot Q_{t-1},$$

where: Q_t is calculated as a weighted average of $\bar{Q}$ (the unconditional covariance of the standardized residuals), $\eta_{t-1}\eta_{t-1}^{'}$ (lagged function of the standardized residuals derived from the first stage univariate GARCH estimation, which is assumed to be n.i.d. with a mean zero and a variance Var_t) and Q_{t-1} (past realization of the conditional covariance).

In this DCC (1, 1) model, alpha and beta are scalar parameters to capture the effects of previous (first lagged realization) standardized shocks and dynamic conditional correlations on current dynamic conditional correlations, respectively. The Q_t expression will be mean-reverting when *alpha* + *beta* < 1. This specification reduces the number of parameters to be estimated and makes the estimation of time-varying correlation more tractable.

3.2 Causality-in-Mean and Causality-in-Variance Analysis

A test developed by Cheung and Ng (1996) to detect the causation patterns in return and volatility for real estate markets and the corresponding local stock markets, for real estate markets and the corresponding regional stock markets, as well as for real estate markets and the global stock market is considered. Specifically, Cheung and Ng (1996) develop a test for CIV to examine the temporal dynamics of return volatilities across national stock markets. It is a natural extension to the well-known Wiener-Granger CIM test. The CIV test is based on the residual cross-correlation function (CCF) and is robust to distributional assumptions. Testing formally for CIV and CIM, is important for our study because real estate markets interact with stock markets in the form of volatility spillover and contagious volatility transmission as witnessed from the recent GFC and literature.

Therefore, after the appropriate multivariate DCC-GJR-GARCH is estimated, we conduct both CIM and CIV tests to detect causal relations and identify pattern of causation in the first and second moments, respectively. Hence, the CCFs of the resulting standardized residuals and squared standardized residuals at k-lags are determined and are used to test the null hypothesis of no CIM and no CIV, respectively between real estate markets and stock markets. The test for a causal relationship at a specified lag k is implemented by comparing $\sqrt{T} \cdot \rho_{i,j}(k)$ with the normal distribution. Here T is the number of time series observations in the sample, $\rho_{i,j}(k)$ is the sample CCF between real estate and stock markets, and k is the number of periods the real estate market lags (k > 0) or leads (k < 0) the stock market. To our knowledge, this is probably the first study in the real estate arena that uses the CIV methodology to evaluate the extent of spillover between real estate and stock markets at the local, regional, and global levels.

3.3 Recursive Akdogan Score Analysis

We apply a method known as recursive integration score analysis developed by Akdogan (1996) to measure long-term integration between the real estate and stock markets from a systematic risk (beta) perspective. Following Liow (2010), three measures of public real estate integration are used to jointly quantify the systematic risk contribution to a three-benchmark portfolio, i.e. between (a) real estate and local stock markets (local score), (b) real estate and regional stock markets (regional score) and (c) real estate and the global stock market (global score) over different time windows. Specifically, the historical figure plots the integration scores from the beginning of the sample period to the end. Extending the end point by one-year observations (52-53 observations) until the end of the period will reflect the marginal impact of adding the one-year observations to the status of integration.

Methodologically, a three index return-generating process R_{jt} of the j^{th} real estate market portfolio can be written as:

$$R_{j,t} = \alpha_j + \beta_{j,gs} R_{gs,t} + \beta_{j,rs} U_{rs,t} + \beta_{j,ls} U_{ls,t} + \varepsilon_j,$$

where:

R_{gs} – global stock market return,

U_{rs} and U_{ls} are obtained as residuals from the following regressions by which the effects from local, regional, and global stock markets are orthogonalized:

$$R_{rs,t} = \lambda + \nu R_{gs,t} + U_{rs,t},$$

$$R_{ls,t} = \lambda + \theta R_{gs,t} + \tau R_{rs,t} + U_{ls,t},$$

where:

R_{rs} – regional stock market return,

R_{ls} – local stock market return.

Decomposing the variance of R_{jt}, we have:

$$Var(R_j) = \beta^2{}_{j,gs} Var(R_{gs}) + \beta^2{}_{j,rs} Var(U_{rs}) + \beta^2{}_{j,ls} Var(U_{ls}) + Var(\varepsilon_j).$$

Dividing both sides by $Var(R_j)$, we have:

$$1 = A_j + B_j + C_j + d_j,$$

where:

$$A_j = \frac{\beta^2_{j,gs} Var(R_{gs})}{Var(R_j)},$$

$$B_j = \frac{\beta^2_{j,rs} Var(U_{rs})}{Var(R_j)},$$

$$C_j = \frac{\beta^2_{j,ls} Var(U_{ls})}{Var(R_j)}, \text{ and}$$

$$d_j = \frac{Var(\varepsilon_j)}{Var(R_j)}.$$

In the above, A_j (global score) is a measure of the j^{th} public real estate market's degree of integration with the global stock market (represented by the MSCI global portfolio). If the real estate market's contribution to the global stock market's systematic risk rises, real estate is becoming more integrated with the global stock market. Similarly, B_j (regional score) measures the j^{th} real estate market's contribution to the regional stock market's systematic risk and C_j (local score) measures the j^{th} real estate market's contribution to the local stock market's systematic risk.

3.4 Principal Component Analysis

To examine the relationship between real estate and stock markets for the nine economies as a group, we use PCA (a popular form of factor analysis) to derive a reduced set of uncorrelated real estate and stock return variables ("principal components" or "factors"), respectively, in terms of linear combinations of the nine original real estate and stock return variables, so as to maximize the variance of these components. To aid factor interpretation, the varimax method of orthogonal rotation is employed, with the Kaiser criterion used to decide on the "factors" that should be retained. As a common rule, those "factors" with an eigenvalue greater than or equal to one are retained. These eigenvalues measure the contributions of the corresponding "factors" to explain the cross-sectional variation of returns in the real estate and stock return sets. Moreover, we are aware that certain factors with eigenvalues close to unity may contain reliable information. As such, they should be retained for subsequent analysis. Finally, since the derived "factors" are linear combinations of real estate returns, local stock returns and regional stock returns, respectively, these three sets of "factors" are expected to also be heteroskedastic. In the second stage, we repeat the conditional correlation analysis, CIM and CIV, as well as the recursive integration score analysis using the respective "factors" derived from the PCA.

3.5 Cross-Asset Market Return Dispersion and Differential

The cross-asset market dispersion is the standard deviation of the various real estate market returns relative to the relevant benchmark stock market returns. The Hodrick-Prescott smoothing technique then follows to estimate the long-term trend component of the series. A large discrepancy in real estate–stock returns across economies, as measured by the cross-asset market return dispersion, will imply that the real estate equity markets are not fully integrated with the corresponding stock markets in the sense of return convergence. In addition, we conduct a 12-month rolling average of the cross-asset market maximum-minimum return differential between real estate and corresponding stock markets. As expected, smaller cross-asset market maximum-minimum return differentials imply greater return convergence.

4 Data

This research includes nine major public real estate markets and stock markets from three regions, namely North America (the US), Europe (France, Germany and the Netherlands and the UK), and Asia-Pacific (Australia, Japan, Hong Kong and Singapore) from a US-based investor's perspective. This requires all the data series to be converted in US dollars. These nine public real estate markets represent about 85% of the global securitized real estate market capitalization and have the world's most significant listed real estate equity markets in the respective regions. Moreover, these nine economies have a developed capital market to enable the growth of the broader stock and public real estate market. However, RREEF (2007) has pointed out that there are significant differences in maturity and behavior of these real estate securities markets. The US has the world's largest real estate market, which is also the most transparent public real estate market. Listed property companies have a long history in Europe. Among them, the UK has the European's largest public real estate market. Together, the UK, France, and the Netherlands account for over 75% of the European public real estate market. While Germany has a long history of indirect real estate vehicles such as open-ended funds, closed-ended funds and listed real estate companies, the Netherlands have an established and relatively large real estate securities market that accounts for about 11% of the European developed public real estate market. In the Asia-Pacific region, Japan as a major world economy has a long tradition of listed real estate, with some of the world's largest "real estate development" companies such as Mitsubishi Estate and Mitsubishi Fudosan. Together with the US, Australia is one of the two most mature public real estate markets, with its listed property trusts (LPTs) as a highly successful indirect real estate investment vehicle. Hong

Kong and Singapore have track record of listed real estate companies that have been playing a relatively important role in the respective local stock market indexes. Finally, REITs have been successfully established in all nine public real estate markets.

The real estate data are weekly FTSE EPRA/NAREIT total return indices maintained by the European Public Real Estate Association (EPRA). These global real estate series are established to track the performance of listed real estate companies and REITs worldwide, as well as act as performance measure of the overall market. The respective stock market indices (i.e. nine local stock markets, three regional markets and a global market) are compiled by the Morgan Stanley Capital Index (MSCI) which are widely used by international fund managers for performance measurement and asset allocation, as well as used by researchers for academic studies.

Our weekly data, obtained from Datastream, are from January 5, 1990 to January 28, 2011, the longest time series data (1,100 weekly observations) that are available for all real estate and stock markets. Weekly real estate and stock returns R are derived by taking the natural logarithm difference of the index times 100. Descriptive statistics of the real estate and stock returns for each of the areas over the study period are displayed in Table 1. As the numbers indicate, the mean weekly real estate return is negative for the UK (-0.0188%) and Japan (-0.0178%), whereas the highest average returns are shown for Hong Kong (0.1635%), the US (0.1137%), and France (0.1135%). Except for France, Hong Kong, and Japan, all six other stock market returns have outperformed the respective public real estate market returns. The range of stock market returns is between -0.0455% (Japan) and 0.1632% (Hong Kong). While the three regional stock markets report a return of 0.1211% (North America), 0.0981% (Europe), and -0.0145% (Asia-Pacific), the global stock market reports a positive weekly return of 0.0755% over the full sample period. In terms of real estate standard deviation, Singapore is the most volatile (5.108%), followed by the Japanese market (4.942%). Comparatively, the stock markets are less volatile with weekly standard deviation ranging between 2.271% (global stock market) and 3.478% (stock market in Hong Kong). Except for Japan, the distribution of returns over time is negatively skewed for all other real estate and stock market series. Additionally, all real estate and stock market returns are characterized by a high kurtosis value over time, implying that the underlying series are leptokurtic. Finally, while the ARCH test indicates the presence of autoregressive conditional heteroskedasticity (ARCH) in all return series, the Augmented Dickey-Fuller (ADF) unit root test indicates all return series are stationary. Figure 1 plots the respective real estate and stock market pairs' index movement over time. In general, the total return co-movements between real estate and local stock markets, real estate and regional stock, as well as real estate and the global stock market differ from one area to another and are difficult to generalize from visual inspection. Hence, further empirical investigations are required to scientifically assess the nature and evolution of the real estate and stock market relationship at the local, regional, and global levels.

– Table 1 and Figure 1 here –

Figure 2 displays the proportion of public real estate market capitalization in the overall stock market over time. With the exception of Hong Kong, Singapore and Australia, public real estate represents only between 0.31% and 3.03% of the local stock market capitalization. Property securities have been playing an important role in the Hong Kong and Singapore economies with the stock market percentage as high as 54.1% (for Hong Kong) and 21.1% (for Singapore) during the period from January 1990 to January 2011. Based on the data compiled from Datastream, public real estate market capitalization is on average about 19.2% (Hong Kong), 8.2% (Singapore) and 8.5% (Australia) of the respective local stock markets' capitalization over the study period.

– Figure 2 here –

5 Empirical Results and Implications

5.1 Dynamic Conditional Correlations

Table 2 presents a summary of the DCC-GJR-GARCH results, obtained using the quasi-maximum likelihood estimation. Since most of the estimated GARCH and asymmetry (GJR), as well as some ARCH parameters are statistically significant, the DCC model appears adequate to capture the temporal dependence of the real estate and stock markets under examination. Moreover, the estimates for the DCC parameters (alpha and beta) are all highly statistically significant, indicating the presence of dynamic (time-varying) correlation between real estate and stock markets. As the sum of alpha and beta is lower than unity, the dynamic correlations move around a constant level and the dynamic process appears to be mean-reverting.

– Table 2 here –

The average conditional correlations between the real estate and stock market pairs are in the range of (0.4518, 0.9165), (0.3819, 0.7634) and (0.3870, 0.5152), respectively, for the local, regional, and global correlations. The average real estate and local stock market correlations in all four Asia-Pacific economies, particularly Hong Kong and Singapore, are (significantly) higher than the corresponding regional and global correlations. These results indicate that the linkage between real estate and stock markets has evolved mainly at the local level in the Asia-Pacific public real estate markets. The higher correlation between real estate and local stock is to be reasonably expected as real estate is a major asset component of these Asian economies. In contrast and with the exception of the UK, the European public estate markets and the US market are more correlated with the regional stock markets than with their respective local stock markets. Finally, all public real estate markets are only moderately correlated with the global stock markets, and are thus able to provide some portfolio diversification benefits in global investing. The evolution of the three real estate and stock market correlation types across the nine economies is displayed in Figure 3. While the three correlation types are quite similar and co-move significantly and positively with one another for the US and the four European economies; the three correlation types have evolved differently over time and the extent of co-movement among them is weaker in the four Asia-Pacific economies.

– Figure 3 here –

To investigate the impact of the 2007 GFC on the DCC, Table 3 compares the DCC magnitudes during the "pre-crisis" (January 2004 – June 2007) and "crisis / post-crisis" (July 2007 – January 2011) periods. With the exception of the linkage between the Japanese real estate market and both the local and regional stock markets, the findings indicate that all the other 25 real estate and stock correlation pairs have registered an increase of between 1.07% and 38.02% (local correlation), between 7.12% and 42.73% (regional correlation), as well as between 6.62% and 65.56% (global correlation), during the "crisis / post-crisis" periods, where the markets were highly volatile. Comparatively, the global correlations report the highest increase of 19.90% (Asia-Pacific average), 24.81% (US), and 38.14% (European average). Beside Japan, the modest effects can be found for Hong Kong and the UK. It is also apparent that the increase in correlation between the local real estate markets and the local stock market is much weaker for the Asia-Pacific markets than for the US and European economies during the "crisis / post-crisis" period. However, at the same time, the level of correlation is much higher in the Asia-Pacific economies during both the "pre-crisis" period and during the "crisis / post-crisis" period. The opposite holds for the linkage between real estate markets and the regional stock markets which might be driven by the high economic and financial integration of the European economies, the European monetary union (EMU), and the corresponding common monetary policy in the EMU.

– Table 3 here –

5.2 Causality Results

The standardized residuals and squared standardized residuals for each real estate and stock market pair are extracted from the respective DCC-GJR models to implement the CCF tests for cross real estate and stock market CIM and CIV. These reported statistics are for causality at a specific lag k. Lags are measured in weeks, which range from -8 to +8. The test results are organized by market pairs and lag order. For a pair of real estate and stock markets, a significant test statistic with lag $k < 0$ should be interpreted that the return and / or variance of the real estate market causes that of the stock market in return and / or variance with a k-period lag. Similarly, if the test statistic is significant with $k > 0$, then the stock market's return and / or variance is said to cause the real estate market in return and / or variance with a k-period lag. A significant test statistic with $k = 0$ indicates contemporaneous causality.

The full period results are reported in Table 4 (for causality between the real estate and local stock markets), in Table 5 (for causality between the real estate and regional stock markets), and in Table 6 (for causality between the real estate and global stock markets). First, none of the real estate markets is contemporaneously linked to its local stock market in returns. In contrast, except for the UK, the other eight real estate markets are linked to their local stock markets contemporaneously through the second moments. Out of the 144 t-statistics that indicate lead-lag relationships, there are only 11 (7.6%) and 9 (6.3%) significant (at least at the 5% level) cases of CIM and CIV respectively. For the local CIM, only the real estate and stock markets of Singapore and the US are linked bilaterally, with another four market pairs report a one-way causality; and the remaining four real estate markets are not linked causally at all with their stock markets. Results for the CIV are slightly weaker with one bilateral, five unilateral and three cases with no causal linkage, respectively, in their real estate and local stock market relationship. Compared with the local relationship, while the current returns between the real estate and regional stock market pairs appear stronger (with six significant contemporaneous relationships), the return causality linkage is weaker (with no case of bilateral CIM and five cases of no lead-lag return linkages). From the CIV perspective, while the variance contemporaneous causality appears weaker, the bilateral causality relationship is detected in two real estate and regional stock market pairs (France and the Netherlands); with one-third of the real estate markets not correlated at all with their regional stock markets through lead-lag volatility linkages. Finally, the global stock market has only moderate degree of causality in return and volatility with the public real estate markets, with bilateral and unilateral CIM and CIV detected in few cases. This evidence is in broad agreement with the extant literature that public real estate markets are fairly segmented from the global stock market.

– Tables 4-6 here –

To examine the influence of the mid-2007 GFC on the causality relationship, the significance and patterns of the CIM and CIV are summarised in Table 7 over two shorter five-year periods: (a) from January 2001 to December 2005 and (b) from January 2006 to January 2011, which covers the GFC period. One key finding is that the lead-lag linkages between the real estate and stock markets appear unstable over the two sub-periods. In Table 7 where three categories of causality are analyzed (bilateral, unilateral and no causality at all), the second sub-period witnesses a change in the CIM relationship for four (real estate and local stock markets), seven (real estate and regional stock markets), and four (real estate and global stock market) pairs; the corresponding number is six (real estate and local stock markets), eight (real estate and regional stock markets), and five (real estate and global stock market) pairs for the CIV relationship. Thus, the GFC happened from mid 2007 has brought fluctuating changes to the causality relationship between real estate and stock markets at the local, regional, and global levels – a finding that is in broad agreement with some prior stock market studies (Fujii, 2005).

– Table 7 here –

5.3 Time-Varying Historical Integration Scores

We examine the individual real estate markets' calculated integration scores (calculated in terms of US dollars): historical A, B, and C for the full study period as described in Section 3.3 (detailed results are not reported in order to conserve space but available from the authors upon request). Integration scores are computed as a fraction of systematic risk in total market risk relative to the three benchmarks. The results provide evidence that over the long run, the selected developed real estate markets could be more integrated with the global stock market (average A scores = 0.2898) while less integrated with their local stock markets (average C scores = 0.1104) and weakly integrated with the regional stock markets (average B scores = 0.0847). However, the average C scores for the Asia-Pacific markets is 0.3202 which is about 20% higher than its A scores (0.2668), implying that the Asia-Pacific public real estate markets (particularly Singapore, Hong Kong, and Australia) are most integrated with their local stock markets while moving toward more integrated with the global stock market over time. Finally, Japan has the highest B scores (0.4008), confirming its dominant regional role in the Asia-Pacific region. This result for the Asia-Pacific markets is consistent with the findings from average correlation in Section 5.1. For the European markets in particular, the GFC 2007 results in a steep increase in the A scores and an almost negligible effect on the B and C scores which is qualitatively also in line with the previous findings above.

Figure 4 plots the cross-market comparison of the historical A, B, and C scores for the real estate markets under examination. The estimates of linear time trend for A, B, and C scores to determine their average increase / decrease over the full period are reported in Table 8. Several findings emerge from this analysis. The historical A scores indicate a moderate increase in global stock integration for seven markets over the last 21 years (the increase ranges between 3.07% and 9.99%). For the B scores, only three markets have registered a small increase of less than one percent each; with other six markets display some changing decline of different degrees of interdependence. Based on the historical C plots, a slow declining trend can be seen in the local stock integration scores for eight of the nine real estate markets. The magnitude of decline in the C scores ranges between 0.03% and 16.48%. Overall, the historical results have provided evidence on the changing pattern of the long-run relationship (i.e. integration) between the selected developed real estate markets and the three benchmark stock markets. It further appears that the markets have displayed some varying and yet slow tendency toward the global stock market while at the same time have shown some changing decline of small degree of integration with the local stock market and regional stock market, to a lesser extent.

– Figure 4 and Table 8 here –

5.4 Principal Component Structure of Real Estate and Stock Returns

We summarize the factor solution using PCA for real estate markets (Panel A), local stock markets (Panel B), and regional stock markets (Panel C) returns in Table 9. The respective Kaiser-Myer-Olkin (KMO) measure of sample adequacy and the Barlett's test of Sphericity (BTS) chi-square statistics imply that the use of the PCA is appropriate. The results from Panel A indicate that the nine real estate return series involve two "factors" which jointly account for 62.65% of the sample variance. In accordance with the weight of each market in each factor (with factor loadings of at least 0.40), the analysis reveals while "Factor 1" is predominantly linked to six markets: the US, Australia, the UK, France, Germany, and the Netherlands, "Factor 2" can be identified with Singapore, Hong Kong, and Japan. For the nine local stock market series (Panel B), the two factors jointly explain about 73.84% of total variance. "Factor 1" is again linked to the US, Australia, the UK, France, Germany, and the

Netherlands. "Factor 2" is shared among the four Asia-Pacific stock markets (i.e. Singapore, Hong Kong, Japan, and Australia). Finally, the factor solution for the three regional stock markets (Panel C) involves only one "factor" which is able to explain about 72.35% of total variance, and is highly correlated with the three regional stock markets.

– Table 9 here –

The study of the individual real estate and stock market pairs is less ideal to detect changes in the general relationship between the real estate and stock markets of the nine economies. However, our factor analysis first reduces the dimensionality from nine to two. Thus it is useful for further examinations of the relationship between real estate and stock markets as two groups and allows for disentangling changes in the overall relationship between real estate and stock markets from country specific effects. While Group 2 is identified with the Asian markets, Group 1 is largely associated with the non-Asian markets:

Group 1 (non-Asian markets):	real estate market factor 1, local stock market factor 1, regional stock market factor, global stock market
Group 2 (Asian markets):	real estate market factor 2, local stock market factor 2, regional stock market factor, global stock market

The factors are first checked for heteroskedasticity. Results of the Lagrange Multiplier (LM) test to detect the presence of ARCH structure of each factor (Table 10) confirm the presence of significant ARCH effects for all factors.

– Table 10 here –

5.5 Group Results: Correlation, Causality, and Integration

Figure 5 shows the three DCC series (local, regional, and global) for the two real estate and stock market groups. Average real estate and stock return co-movements for the nine pairs of markets as a group are 0.6223 (local correlation), 0.4510 (regional correlation), and 0.4214 (global correlation). Moreover, visual inspections of the various correlation series indicate that the pattern of correlation evolution appears to diverge significantly across the two groups. Additional analysis reveals that while the correlation risk for the six correlation series ranges between 5.65% (Asian: local) and 24.31% (non-Asian: global), the average change has been very minimal (between -0.17% and 0.51%) over the last two decades. Thus, these correlations between real estate and stock markets at the three levels might be mean-reverting.

– Figure 5 here –

Turning to the causality results, in general we find that real estate markets are significantly correlated with the local, regional, and global stock markets in their contemporaneous returns and variances; with the only exception that the real estate and local stock markets are not correlated in their current returns. The following causal relations are observed: (a) bilateral mean causality between Asia-Pacific real estate and local stock markets, as well as bilateral mean causality between non-Asian real estate and regional stock markets; and (b) return and volatility spillovers from the real estate to stock markets at the three integration levels (unilateral causality). The overall conclusion is that the developed real estate and stock markets are linked through their co-movement and spillovers in both return and volatility at the local, regional, and global levels, with more instances of lead-lag linkages observed at the local level.

Finally, Table 11 reveals that the average integration scores fluctuate between 0.2630 and 0.3382 (global scores), between 0.0231 and 0.0919 (regional scores), and between 0.1082 and 0.3745 (local scores), indicating that the developed real estate markets (as a group) are more integrated with the global and local stock markets while largely segmented from the regional stock markets in the long run. The C scores for the Asian group (RE2C: 0.3745) are much higher than its A scores (RE2A: 0.2630), confirming that on average, Asian public real estate markets are more integrated with their local stock markets in the long run. From Figure 6 which plots the historical integration scores (A, B and C) for the two real estate groups, it is evident that the respective integration scores are time-varying, with increasing A scores, decreasing C scores, as well as mixed variation in B scores for the two real estate groups. The percentage increase in the A scores and the percentage decrease in the C scores, in particular are similar for the two groups of Asian and non-Asian real estate markets. However, while the regional B scores slightly decrease over time for the Asian markets, there is an increase of more than 13% for the factor of the non-Asian markets indicating a continuous market integration process over time between real estate and regional stock markets but at a low level. This also further strengthens the finding from Section 5.1 and Section 5.3 based on individual markets. Taking the two groups as a whole, the linear trend results reveal that there is an increase of between 7.80% and 10.01% in the A scores, a change of between -1.13% and 13.87% in the B scores, as well as a decline of about 10% in the C scores, over the last two decades. Thus, our results imply that the world's major public real estate markets have slowly become more integrated with the global and regional stock markets; while less integrated with the local stock market.

– Table 11 and Figure 6 here –

5.6 Cross-Asset Market Return Dispersion and Return Differential

Figure 7a presents the Hodrick-Prescott filtered return dispersion between real estate market returns and local stock market factor 1 returns (non-Asia), as well as between real estate market returns and local stock market factor 2 returns (Asia-Pacific). As can be observed, the evolution of cross real estate-stock return relationship has been associated with several fluctuations over the last two decades. For the four Asia-Pacific economies, declining cross-return dispersion is detected from a high of 123 basis points (bps) during the Asian Financial Crisis to a low of about 40 bps at about the end of September 2005. However, the cross-return dispersion has trended upwards and widened to 113 bps by end of October 2008. Since then, the cross-return dispersion has been rapidly decreasing implying a tendency of cross-return convergence in the four Asia-Pacific economies. Similarly, the five non-Asian economies have experienced a declining cross-market dispersion pattern from a high of 103 bps at August 2002, to a low of about 45 bps at November 2004, trended upward to 158 bps at January 2009 and appeared to converge thereafter. Figure 7b (regional evolution) and Figure 7c (global evolution) indicate broadly similar trends of the convergence process. Following a period of fluctuating cross-convergence after the Asian Financial Crisis, the real estate and stock integration processes pick up at the local, regional, and global levels after the GFC. Some indication of falling maximum-minimum cross return differentials also exhibits for the non-Asian group (Figure 8a) and Asia-Pacific group (Figure 8b) after year 2008. However, the integration process is far from complete.

– Figure 7a-7c and Figure 8a-8b here –

5.7 Implications of Findings

Given the focus of each of the approaches and associated indicators, the picture that emerges from the empirical results is not completely uniform. Nevertheless, our results underscore the complexity of cross real estate and stock market relationship at the local, regional, and global levels in three important dimensions: time-dependent return co-movement, changing return and volatility spillover and causation, as well as time-varying integration and fluctuating convergence. The statistical approaches considered are dynamic conditional correlation methodology, causality-in-mean and causality-in-variance tests, recursive integration score techniques, factor analysis, and cross-return dispersion and differentials. The combination of these approaches used in this study thus represents a modest methodological contribution to the extant literature in international investing.

Our results are useful for both practitioners and academics in understanding the dynamic relationships between the major developed public real estate and local stock markets, between the real estate and regional stock markets, as well as between the real estate and global stock markets in the growing context of economic globalization and increasing real estate securitization. In particular, this study serves to remind international investors who are keen to include developed real estate equities and common stocks in their portfolios with at least three major economic implications in their portfolio decisions:

First, the dynamic conditional correlation results provide investors with useful knowledge regarding the extent to which the major public real estate markets are correlated with the stock markets at the local, regional, and global levels. What has emerged from this study is that while the current levels of correlations between real estate markets and local, regional, and global stock markets are time-varying and are at most moderate at the respective integration levels, there are important regional differences. Specifically, the average correlation between real estate and local stock markets in all four Asia-Pacific economies, particularly Hong Kong and Singapore, are (significantly) higher than the corresponding regional and global correlations, indicating that the real estate-stock market correlation has evolved mainly at the local level in the Asia-Pacific public real estate markets. In contrast and with the exception of the UK, the European public real estate markets and the US market are more correlated with the regional stock markets than their respective local stock markets. Also, all public real estate markets are only moderately correlated with the global stock markets, and are thus able to provide some portfolio benefits in global investing. Such knowledge would be very useful for those international investors who practice regional diversification. In addition, real estate and stock markets could become more correlated in periods of high volatility, as the GFC episode has indicated. Thus, an important lesson learnt from this examination is that the dynamic real estate and stock market conditional correlations are critical in identifying the optimal long-run portfolio allocation for real estate and stocks across different economies with non-uniform degree of real estate and stock correlations at the local, regional, and global levels.

Second, in understanding the spillover effects of return and volatility between the developed real estate and stock markets, although there are instances of lead-lag linkages in return and variance at the three real estate-stock market integration levels, the extent of return and volatility spillovers between the real estate and stock markets is weaker than the contemporaneous linkages in return and variance between the real estate and stock markets at the three integration levels. The economic and policy implications regarding causality would clearly be important, as the evidence cautions policy makers that domestic real estate market policies should not be implemented without taking in account the possible co-movement and causality impacts on the relationship between real estate and stock markets at the local, regional, and global stock markets and vice versa. From the international investors' perspective, there would be little diversification benefits if the real estate market is causally linked to the local, regional, and global stock markets in returns or volatilities.

Finally, our empirical recursive integration score analysis provides investors with useful knowledge regarding the relative importance of the three real estate and stock market integration types. The three levels of integration are evaluated simultaneously via a three stock benchmark model with an intuitive decision rule; i.e. the higher the score, the higher the level of integration. One important lesson to learn from the integration score analysis is that the long-run relationship between real estate and stock markets (i.e. co-integration) could be different from the short-run linkage (i.e. correlation). Specifically, while our short-run DCC-GJR analysis reveals that the real estate markets are least correlated with the global stock market; the integration score analysis reveals that the real estate markets have, on average, slowly become more integrated with the global and partly regional stock markets; while less integrated with the local stock market in the long run. From the portfolio management perspective, it is thus important for global investors to include the time-varying correlation and spillovers, as well as recursive integration score information, in order to be able to understand better the changing real estate-stock market relationship at the three integration levels from the short-term and long-run perspectives.

6 Conclusion

This study focuses on the nature and evolution of the dynamic relationship between nine major developed public real estate and stock markets at the local, regional, and global levels over a period beginning January 1990 and ending January 2011. Our analysis is also extended to the recent GFC to assess its impact on the co-movement, causality, and integration of real estate and stock markets.

For individual pairs of real estate and stock markets, the DCC-GJR analysis indicates that the current levels of local, regional, and global real estate and stock market correlations are time-varying and are at most moderate at the respective integration levels. The average conditional correlation between real estate and local stock markets in the Asia-Pacific economies are (significantly) higher than the corresponding regional and global conditional correlations; while the non Asia-Pacific public estate markets are generally more correlated with the regional stock markets than with their respective local stock markets. Also, real estate and stock markets have become more correlated in periods of high volatility, as the GFC episode has indicated for all markets and the Asian crisis in 1997 and 1998 for the Asian markets in particular. Mean and variance causality analysis reveals that there are instances of contemporaneous and lead-lag interactions in return and volatility between real estate and stock markets; however the causality relationship appears weaker. Further, the mean and variance causality linkages between the real estate and stock markets appear unstable over the "pre-crisis" and "crisis / post-crisis" periods. Finally, recursive integration score analysis implies that the real estate markets have, on average, slowly become more integrated with the global and regional stock markets; while less integrated with the local stock market in the long run.

In examining the relationship between real estate and stock markets for the nine economies as a group, we are able to obtain more directly the general co-movement between real estate and stock markets using factor analysis whose input for analysis is the correlation matrix of returns. For the three groups that include nine real estate markets, nine local stock markets, and three regional stock markets, we are able to extract five common factors that generate returns – namely two real estate factors, two local stock market factors, and one regional common stock market factor. Not only that the nature of the factor structure allows us to associate two (real estate and local stock markets) factors reasonably clear to two groups (Asia and non-Asia), these extracted factors also allow us to incorporate the DCC, CIV and recursive integration score to assess directly the dynamic relationships between real estate and stock markets as a group, and thereby complements the individual results. Finally, an interesting extension of this study with an even broader focus and probably interesting findings and implications is a mixed asset portfolio scenario because commodity markets and real estate markets show low correlations with common stock and bond markets and thus attract more and more attention by investors looking for diversification opportunities.

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Tables

Table 1: Descriptive Statistics of Real Estate and Stock Market's Weekly Returns: January 1990 to January 2011

	Public Real Estate Markets						Stock Markets					
	Mean (%)	**S.D. (%)**	**Skewness**	**Kurtosis**	**ARCH(10)**	**ADF**	**Mean (%)**	**S.D. (%)**	**Skewness**	**Kurtosis**	**ARCH(10)**	**ADF**
Japan	-0.0178	4.942	0.3028	4.4901	11.011***	-19.768***	-0.0455	3.119	0.0658	4.6518	7.586***	-18.967***
Hong Kong	0.1635	4.484	-0.4135	6.7636	4.801***	-17.155***	0.1632	3.478	-0.4808	5.832	7.629***	-17.607***
Singapore	0.0501	5.108	-0.7388	18.623	15.281***	-15.842***	0.105	3.331	-0.6272	10.9435	10.752***	-17.018***
Australia	0.0384	3.375	-2.9043	36.0022	42.304***	-17.997***	0.119	3.069	-1.7105	19.5438	13.901***	-18.851***
US	0.1137	3.372	-0.0253	33.3221	73.671***	-17.869***	0.1202	2.371	-0.7783	10.1706	20.147***	-19.369***
UK	-0.0188	3.371	-1.2797	12.2253	35.044***	-18.014***	0.0786	2.725	-1.0542	15.9163	27.994***	-20.239***
France	0.1135	3.026	-1.1609	11.5117	16.260***	-18.048***	0.0973	3.046	-0.8977	10.2295	16.391***	-19.328***
Germany	0.0252	3.993	-1.2127	14.488	20.175***	-18.211***	0.0961	3.33	-0.794	8.7119	24.507***	-20.196***
Netherlands	0.0122	2.864	-1.4297	13.0109	24.542***	-18.406***	0.1076	2.949	-1.5565	17.5682	5.981***	-19.746***
Asia-Pacific							-0.0145	2.874	-0.2484	5.8573	7.895***	-18.572***
Europe							0.0981	2.684	-1.2484	14.865	20.649***	-19.351***
North America							0.1211	2.372	-0.8201	10.7749	21.548***	-19.302***
Global							0.0755	2.271	-1.1071	13.7051	18.141***	-19.021***

Notes: Statistical significance at the 1% level is indicated by ***.

Table 2: Multivariate DCC (1, 1)-GJR-GARCH (1, 1) Estimates (1: Real Estate; 2: Local Stocks; 3: Regional Stocks, 4: Global Stock)

	Japan	Hong Kong	Singapore	Australia	US	UK	France	Germany	Netherlands
ARCH(1)	0.0224	0.0594**	0.0137	0.0843***	0.0856	0.0009	0.0299**	0.1761***	0.0472
ARCH(2)	0.0371*	0.0649***	0.0379*	0.0463*	0.0314	0.0253	0.0009	0.0067	0.0498
ARCH(3)	0.0250	0.0250	0.0250	0.0250	0.0313	0.0013	0.0013	0.0013	0.0013
ARCH(4)	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120	0.0120
GARCH(1)	0.9020***	0.8438***	0.9068***	0.8884***	0.8393***	0.9283***	0.9599***	0.7253***	0.9484***
GARCH(2)	0.8544***	0.8603***	0.8824***	0.8381***	0.8384***	0.8145***	0.8241***	0.7170***	0.7686***
GARCH(3)	0.8495***	0.8495***	0.8495***	0.8495***	0.8450***	0.7819***	0.7819***	0.7819***	0.7819***
GARCH(4)	0.8791***	0.8791***	0.8791***	0.8791***	0.8791***	0.8791***	0.8791***	0.8791***	0.8791***
GJR(1)	0.1028***	0.1236*	0.1137***	0.0357	0.1018*	0.0864***	0.0136	0.0715	0.0049
GJR(2)	0.1031*	0.0976*	0.1234***	0.1146*	0.1937**	0.2365**	0.1927	0.3033**	0.2415
GJR(3)	0.1183*	0.1184*	0.1184*	0.1184*	0.1851**	0.2602*	0.2602*	0.2602*	0.2602*
GJR(4)	0.1754**	0.1754**	0.1754**	0.1754**	0.1754**	0.1754**	0.1754**	0.1754**	0.1754**
Alpha	0.0368***	0.0311***	0.0275***	0.0229***	0.0431***	0.0259***	0.0249***	0.0283***	0.0300***
Beta	0.9483***	0.9477***	0.9601***	0.9719***	0.9458***	0.9609***	0.9694***	0.9598***	0.9537***
Alpha + Beta	0.9851***	0.9788***	0.9876***	0.9948***	0.9889***	0.9868***	0.9943***	0.9881***	0.9837***
Average Correlation (1-2)	0.7800	0.9165	0.7918	0.7476	0.5354	0.6279	0.4755	0.4518	0.4819
Average Correlation (1-3)	0.7634	0.4498	0.4498	0.3819	0.5358	0.6032	0.5009	0.4814	0.4980
Average Correlation (1-4)	0.4905	0.4859	0.4737	0.4249	0.4787	0.5152	0.3870	0.3914	0.3932

Notes: Statistical significance at the 1%, 5%, and 10% level is indicated by *, **, and *** respectively.

Table 3: Average Correlation between Real Estate Equity and Stock Markets before and after the Global Financial Crisis

	Local Stock Market			Regional Stock Market			Global Stock Market		
Public Real Estate Market	**Pre-Crisis**	**Post-Crisis**	**Difference**	**Pre-Crisis**	**Post-Crisis**	**Difference**	**Pre-Crisis**	**Post-Crisis**	**Difference**
Japan	0.7945	0.7753	-2.42%	0.7805	0.7539	-3.41%	0.4863	0.5185	6.62%
Hong Kong	0.9150	0.9248	1.07%	0.4963	0.6221	25.35%	0.5253	0.5705	8.60%
Singapore	0.7748	0.8477	9.41%	0.4752	0.6490	36.57%	0.5042	0.6478	28.48%
Australia	0.7636	0.8163	6.90%	0.466	0.6651	42.73%	0.4822	0.6587	36.60%
Asian Average	0.8120	0.8410	3.57%	0.5545	0.6726	21.30%	0.4995	0.5989	19.90%
US	0.5401	0.6942	28.53%	0.54	0.6887	27.54%	0.5059	0.6314	24.81%
UK	0.6925	0.7457	7.68%	0.6702	0.7179	7.12%	0.5819	0.6624	13.83%
France	0.5352	0.7387	38.02%	0.5609	0.7419	32.27%	0.4496	0.7039	56.56%
Germany	0.5155	0.6774	31.41%	0.5813	0.7203	23.91%	0.4529	0.6649	46.81%
Netherlands	0.5049	0.6772	34.13%	0.5749	0.7235	25.85%	0.4669	0.6649	42.41%
Europe Average	0.5620	0.7097	26.28%	0.5968	0.7259	21.63%	0.4879	0.674	38.14%

Notes: Pre-crisis (Pre-global financial crisis period: January 9, 2004 – June 29, 2007); Post-crisis (during and post-global financial crisis period: July 6, 2007 – January 28, 2011).

Table 4: Causality-in-Mean (CIM) and Causality-in-Variance (CIV) Test Statistics – Real Estate Markets and Local Stock Markets – from January 1990 to January 2011

	Causality-in-Mean (CIM)									Causality-in-Variance (CIV)								
Lag (k)	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**
-8	-1.37	1.17	-0.83	0.57	-0.77	1.07	0.50	0.77	0.53	-0.27	**3.13***	1.30	-0.80	0.07	-0.10	0.83	0.97	-1.27
-7	1.07	**2.17***	**3.03***	-0.03	-0.87	0.13	-0.37	-0.10	0.53	0.40	1.13	-0.53	-0.83	0.97	**2.77***	-0.90	1.30	-1.00
-6	0.77	0.97	**2.30***	0.13	1.77	-0.07	0.77	1.50	0.00	0.00	-0.30	-0.30	-0.80	-0.07	-0.57	-0.97	0.80	-1.40
-5	0.97	-1.50	0.13	-0.20	**2.67***	-0.40	1.00	1.17	0.10	-0.60	0.30	0.63	**8.70***	0.47	0.57	1.17	-0.27	-0.13
-4	0.80	0.43	-0.50	0.97	1.07	-0.80	-0.27	-0.20	**-2.23***	-0.50	1.73	1.13	-0.40	-0.73	-1.03	-0.23	-0.07	0.60
-3	-1.17	1.70	0.53	0.20	-0.90	0.03	1.23	-1.10	**2.07***	**2.50***	-0.20	-0.47	0.50	-0.70	-1.10	1.20	-0.57	-0.43
-2	-0.23	0.33	0.20	0.67	1.90	0.07	0.77	1.33	0.97	0.20	-0.53	-0.13	**2.80***	0.27	**4.03***	1.07	**3.97***	**5.13***
-1	0.93	0.50	**2.73***	0.47	0.90	-0.10	1.77	1.37	1.63	1.57	1.00	0.10	0.07	1.20	1.63	0.27	0.00	1.33
0	0.57	0.53	1.07	1.37	0.63	0.57	0.37	0.83	1.60	**3.17**	**4.40***	**6.03***	**5.47***	**3.07***	1.23	**2.23***	**2.67***	**4.97***
1	0.80	1.07	**2.47***	-0.10	-0.17	1.07	0.80	-0.40	-0.13	1.43	0.20	0.47	-0.63	0.70	1.83	0.63	0.47	0.23
2	1.60	1.47	1.93	0.17	-0.40	0.67	-0.20	-1.40	-0.07	1.00	0.87	0.63	0.07	0.80	-0.23	0.70	0.13	-0.23
3	1.10	-0.73	0.63	-1.23	-1.20	-0.63	1.30	-0.27	-0.47	1.03	-0.10	1.30	-0.23	-0.37	-1.03	-0.47	-0.17	1.33
4	**3.33***	-1.23	0.10	0.20	-1.93	-1.57	0.50	-0.13	-0.60	1.40	1.70	-0.43	0.90	-1.53	0.90	-1.73	-0.40	-0.63
5	-0.73	0.23	1.57	0.93	**-2.97***	-0.63	0.07	**-2.20***	0.97	-0.83	-0.53	1.60	-0.37	-0.87	0.27	-1.27	0.27	0.80
6	0.30	0.30	-0.87	-0.07	0.07	-0.20	1.23	0.33	-0.80	0.33	-0.07	0.00	-0.50	-0.97	-0.17	-0.33	0.17	-1.53
7	0.10	0.00	0.47	0.73	-1.10	-0.63	-0.50	1.23	-0.57	0.13	-0.33	-1.10	-1.13	-0.23	-1.37	-0.43	0.17	-0.23
8	1.23	-1.80	1.77	1.93	0.20	0.73	0.70	-1.50	-1.20	-0.40	1.40	0.27	**2.43***	-0.63	-0.73	-0.90	-0.53	0.20

Notes: Reported test statistics are for causality at a specified lag k. Lags are measured in weeks, which range from -8 to +8. A significant test statistic (in bold with an asterisk - at least significant at the 5% level) with lag k = 0 indicates contemporaneous causality. If the test statistic is significant with k < 0, then the return/variance of the first market (real estate market) is said to cause that of the second market (stock market) in return /variance with a k-week lag; whereas a significant test statistic with lag k > 0 implies that the second market (stock market)'s return/variance causes the first market (real estate market) in return /variance at k^{th} lag. Legends: JP(Japan) HK (Hong Kong), SG (Singapore), AUS (Australia), US (United States), UK (United Kingdom), FR (France), GER (Germany) and NL (Netherlands).

Table 5: Causality-in-Mean (CIM) and Causality-in-Variance (CIV) Test Statistics – Real Estate Markets and Regional Stock Markets – from January 1990 to January 2011

	Causality-in-Mean (CIM)									Causality-in-Variance (CIV)								
Lag (k)	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**
-8	-0.93	-0.80	1.33	-0.07	0.53	1.03	1.00	1.53	1.27	-1.73	0.23	1.07	-0.93	-0.37	-1.03	0.67	-0.80	0.87
-7	0.70	-0.83	1.67	-0.30	1.07	1.57	0.30	0.17	1.77	-0.80	-0.63	1.40	-0.27	-0.30	**3.30***	1.63	1.30	**2.33***
-6	0.10	0.47	0.37	0.20	0.73	-0.23	-0.03	0.50	-0.33	-0.77	-0.43	-0.13	-0.50	0.20	-0.80	-0.77	0.40	-0.33
-5	1.00	0.37	0.80	0.20	-0.70	0.07	1.27	1.00	1.33	0.83	0.00	-0.80	-1.20	0.47	1.00	**3.27***	0.37	**4.40***
-4	0.17	-0.70	0.77	-0.77	1.60	0.57	0.87	-0.40	0.13	-0.63	-0.10	-0.83	-0.63	0.37	-0.03	-0.57	0.73	-0.33
-3	-0.70	0.23	-0.87	0.10	1.03	0.37	-0.10	0.73	-0.17	1.87	-1.60	0.17	-0.50	-0.03	-0.67	-0.60	-0.30	-0.77
-2	-0.50	-0.30	**2.07***	-1.30	-0.63	0.07	0.60	1.40	0.30	0.57	0.10	0.23	-1.03	0.60	1.40	0.17	-0.30	-0.53
-1	-0.37	-0.70	**2.20***	0.80	-0.23	0.03	-0.30	2.47	0.87	1.57	-0.10	-0.13	1.27	1.53	1.47	-0.70	-0.70	0.30
0	**15.37***	**4.17***	**4.20***	-0.07	0.10	**5.73***	**4.00***	**3.73***	0.80	**8.63***	**2.13***	0.20	1.17	**4.63***	1.40	**2.30***	**3.47***	**3.20***
1	0.23	-0.20	1.00	0.60	0.80	-1.13	0.80	-0.13	0.07	0.40	-0.07	0.13	0.23	-0.43	-0.37	0.33	0.23	-0.77
2	1.07	1.40	0.13	0.93	0.70	-0.47	-0.23	0.23	1.33	-0.80	-0.47	0.37	0.37	-0.03	-0.50	-0.93	0.10	-0.90
3	0.93	-0.70	0.73	1.17	-0.13	-1.27	0.33	-0.83	0.90	**3.27***	-0.27	**2.60***	-0.40	1.47	-0.37	-0.17	-1.33	-1.00
4	**2.07***	0.13	-1.83	1.00	0.03	-0.97	-0.43	-0.57	-0.73	0.23	0.67	0.43	-0.13	-0.50	-1.37	**-2.20***	-1.17	-0.53
5	-0.90	0.17	1.03	0.13	0.50	-1.10	1.07	-0.07	-0.63	**-2.50***	1.87	-0.30	-0.83	-1.10	-1.10	-0.93	-0.53	-1.17
6	0.53	0.47	-1.10	-1.33	0.43	-0.80	1.23	-0.63	0.60	-0.73	0.87	-0.20	-0.83	-1.10	-0.60	-0.90	-1.23	**-2.30***
7	0.40	-1.00	-0.63	**-2.20***	-0.57	-0.83	0.30	-0.67	-0.60	0.17	**3.00***	-0.90	0.80	-0.70	0.33	0.13	-0.20	-1.03
8	1.90	0.10	-0.57	1.53	**-2.10***	0.93	0.60	-0.63	0.23	-0.37	1.73	0.73	-0.43	-0.90	-0.90	0.67	-0.67	-1.07

Notes: Reported test statistics are for causality at a specified lag k. Lags are measured in weeks, which range from -8 to +8. A significant test statistic (in bold with an asterisk - at least significant at the 5% level) with lag k = 0 indicates contemporaneous causality. If the test statistic is significant with k < 0, then the return/variance of the first market (real estate market) is said to cause that of the second market (stock market) in return /variance with a k-week lag; whereas a significant test statistic with lag k > 0 implies that the second market (stock market)'s return/variance causes the first market (real estate market) in return /variance at k^{th} lag. Legends: JP(Japan) HK (Hong Kong), SG (Singapore), AUS (Australia), US (United States), UK (United Kingdom), FR (France), GER (Germany) and NL (Netherlands).

Table 6: Causality-in-Mean (CIM) and Causality-in-Variance (CIV) Test Statistics – Real Estate Markets and Global Stock Market – from January 1990 to January 2011

	Causality-in-Mean (CIM)									Causality-in-Variance (CIV)								
Lag (k)	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**	**JP**	**HK**	**SG**	**AUS**	**US**	**UK**	**FR**	**GER**	**NL**
-8	1.37	-0.27	-0.57	0.67	-0.20	1.00	-0.30	0.90	0.17	0.23	-0.27	-0.57	-0.63	-0.93	-0.27	-0.23	-0.93	-0.73
-7	0.30	0.37	0.70	0.70	-0.23	0.80	0.27	0.60	0.33	0.77	1.33	1.17	-0.93	-0.87	0.70	-0.37	-0.63	0.27
-6	-0.20	-1.13	0.83	-0.97	**2.00***	0.17	-1.30	0.13	-1.83	0.73	-0.43	0.00	-0.53	0.23	0.60	0.60	-1.00	0.83
-5	1.93	-0.37	-0.40	0.53	1.00	1.73	-1.30	0.50	1.73	0.57	-0.83	-0.53	-0.43	0.07	-0.47	-0.10	-0.20	-0.57
-4	-0.70	-0.20	0.07	**-2.40***	1.23	-0.97	0.80	0.63	0.37	-0.77	0.07	0.87	-0.77	-0.57	0.03	1.03	-0.17	-0.83
-3	0.10	-0.03	0.30	1.17	-0.37	0.97	-0.23	1.40	1.40	1.30	0.27	-0.07	1.47	-0.17	**2.50***	**2.07***	0.57	**2.50***
-2	-0.60	0.67	1.83	0.60	1.53	**2.40***	-0.20	-0.60	-1.63	0.07	0.43	-0.43	0.10	-0.03	-0.87	0.13	-0.80	0.80
-1	0.93	0.20	**2.07***	1.63	-0.70	0.03	1.83	0.53	1.93	0.97	-0.07	0.53	**7.70***	0.57	1.50	**2.20***	0.90	**5.03***
0	**7.43***	**4.40***	**5.07***	**3.30***	**6.33***	**2.97***	0.50	**1.97***	0.13	1.63	**2.07***	**2.90***	1.33	**5.97***	**5.27***	**2.97***	**9.83***	1.93
1	0.70	-0.50	1.50	1.13	-0.27	0.93	0.00	-0.60	-0.07	0.87	0.83	**3.13***	-0.47	1.23	0.33	-1.57	-0.70	-0.27
2	0.80	**2.40***	1.57	1.60	0.43	1.00	**2.13***	-0.97	0.47	0.30	0.70	-1.17	0.00	0.27	0.87	1.20	-0.03	0.53
3	0.03	-0.67	0.03	-0.10	0.13	-0.03	-0.03	0.20	0.53	1.80	-1.37	0.47	0.57	0.13	1.07	-0.73	1.07	1.23
4	**2.50***	0.27	-0.73	0.07	-1.17	1.20	0.43	-0.67	0.53	1.30	-0.13	-0.50	-0.90	0.77	-0.97	-1.00	0.57	-1.07
5	-1.73	0.27	-0.80	-1.90	-0.93	-0.07	-0.03	-0.57	-0.07	1.50	-0.27	-0.63	-0.90	-0.17	-0.07	-0.13	0.00	-0.23
6	-0.90	-0.40	0.27	0.17	0.10	0.80	-1.20	1.73	-0.27	0.43	0.17	0.57	0.53	-1.00	-1.27	**-2.37***	-1.70	-1.87
7	-0.27	-1.10	-0.20	0.07	-0.23	-1.17	0.30	-0.33	-1.63	-0.33	-0.23	0.77	0.37	-1.00	-0.07	-0.20	0.03	0.30
8	-0.33	-1.13	-0.23	1.57	-0.60	**2.00***	1.13	-0.03	**2.10***	0.70	1.13	-0.07	-0.77	-0.77	-0.93	0.77	-0.23	-0.13

Notes: Reported test statistics are for causality at a specified lag k. Lags are measured in weeks, which range from -8 to +8. A signif0cant test statistic (in bold with an asterisk - at least significant at the 5% level) with lag k = 0 indicates contemporaneous causality. If the test statistic is significant with k < 0, then the return and / or variance of the first market (real estate market) is said to cause that of the second market (stock market) in return and / or variance with a k-week lag; whereas a significant test statistic with lag k > 0 implies that the second market's (stock market) return and / or variance causes the first market (real estate market) in return and / or variance at the k^{th} lag. Legends: JP(Japan) HK (Hong Kong), SG (Singapore), AUS (Australia), US (United States), UK (United Kingdom), FR (France), GER (Germany) and NL (Netherlands).

Table 7: Direction of Causality-in-Mean (CIM) and Causality-in-Variance (CIV): Pre- and Post-Global Financial Crisis Periods

	Real Estate - Local Stock				Real Estate - Regional Stock				Real Estate - Global Stock			
	CIM		CIV		CIM		CIV		CIM		CIV	
	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis	Pre-Crisis	Post-Crisis
Japan	unilateral	unilateral	no	no	unilateral	unilateral	no	unilateral	bilateral	no	unilateral	bilateral
Hong Kong	unilateral	unilateral	unilateral	bilateral	unilateral	no	unilateral	unilateral	unilateral	unilateral	no	unilateral
Singapore	unilateral	unilateral	unilateral	bilateral	no	unilateral	unilateral	no	no	no	unilateral	unilateral
Australia	unilateral	unilateral	no	unilateral	no	no	no	unilateral	no	no	unilateral	unilateral
US	bilateral	no	no	no	unilateral	no	unilateral	no	no	bilateral	no	no
UK	no	unilateral	unilateral	no	unilateral	no	no	unilateral	no	no	no	bilateral
France	bilateral	no	unilateral	no	bilateral	no	no	unilateral	unilateral	no	no	unilateral
Germany	unilateral	no	unilateral	no	no	bilateral	no	unilateral	no	no	no	unilateral
Netherlands	no	no	unilateral	unilateral	no	unilateral	no	unilateral	unilateral	no	unilateral	unilateral

Notes: The direction of causality (in-mean and in-variance) for real estate-local stock, real estate-regional stock and real estate-global stock pairs is classified into three groups, and the results for both pre- (January 2001 – December 2005) and post (January 2006 – January 2011) – global financial crisis periods are compared. "Bilateral" causality means that there are lead-lag interactions between real estate and stock markets (i.e. from lagged real estate to stock and from lagged stock to real estate markets); "Unilateral" causality means either real estate causes stock or stock causes real estate markets (and not both) and "no" means that there is no lead-lag interaction between real estate and stock markets.

Table 8: Estimated Coefficient (β) of Linear Time Trend for Integration Scores

	A Scores		B Scores		C Scores	
	Coefficient	**% Change**	**Coefficient**	**% Change**	**Coefficient**	**% Change**
Japan	0.00146	3.07%	-0.00051	-1.07%	-0.000035	-0.07%
Hong Kong	0.00429***	9.01%	0.000333***	0.70%	-0.007846**	-16.48%
Singapore	0.002347**	4.93%	0.000331*	0.70%	-0.003436***	-7.22%
Australia	0.003015***	6.33%	-0.00028	-0.59%	-0.00606**	-12.73%
US	-0.005194	-10.91%	-0.00757*	-15.90%	-0.000015	-0.03%
UK	0.001873*	3.93%	-0.000726	-1.52%	0.00059	1.24%
France	0.004758***	9.99%	-0.001944*	-4.08%	-0.000265**	-0.56%
Germany	0.004301***	9.03%	0.000304	0.64%	-0.000528	-1.11%
Netherlands	0.004269***	8.96%	-0.001943	-4.08%	-0.002331***	-4.90%

Notes: $Score_j = \alpha_j + \beta_j \cdot T + \varepsilon_j$, where ε is an error term. Linear time trend coefficient - % increase / decrease over the full period: 21 years.

Table 9: Principal Component Analysis (with Varimax Rotation) of Weekly Returns: from January 1990 to January 2011

Panel A: Real Estate Returns

Real Estate Return	**Component**	
	Factor 1	**Factor 2**
US	0.562	0.219
UK	0.779	0.233
France	0.875	0.146
Germany	0.760	0.192
Netherlands	0.879	0.170
Singapore	0.205	0.840
Japan	0.221	0.546
Hong Kong	0.165	0.854
Australia	0.666	0.341
% of Variance Explained	49.019	13.635
Cumulative % of Variance Explained	49.019	62.654
Eigenvalue	4.412	1.227
Kaiser-Myer-Olkin (KMO)	0.881	
Barlett's Test of Sphericity (BTS)	Chi-square = 4455.44 (p= 0.000)	

Panel B: Local Stock Returns

Local Stock Market	**Component**	
	Factor 1	**Factor 2**
US	0.779	0.252
UK	0.828	0.243
France	0.883	0.300
Germany	0.861	0.304
Netherlands	0.875	0.295
Singapore	0.222	0.806
Japan	0.210	0.691
Hong Kong	0.270	0.796
Australia	0.594	0.532
% of Variance Explained	63.028	10.812
Cumulative % of Variance Explained	63.028	73.840
Eigenvalue	5.673	0.973
Kaiser-Myer-Olkin (KMO)	0.929	
Barlett's Test of Sphericity (BTS)	Chi-square = 7495.41 (p= 0.000)	

Panel C: Regional Stock Returns

Regional Stock Market	**Factor 1**
North Americas	0.863
Europe	0.917
Asia-Pacific	0.764
% of Variance Explained	72.348
Cumulative % of Variance Explained	72.348
Eigenvalue	2.170
Kaiser-Myer-Olkin (KMO)	0.633
Barlett's Test of Sphericity (BTS)	Chi-square = 1302.67 (p= 0.000)

Table 10: Lagrange Multiplier (LM) Tests for ARCH Structure in the Factors Derived from the Principal Component Analysis (PCA)

Lag (k) in ARCH Structure	Real Estate Factor 1	Real Estate Factor 2	Local Stock Factor 1	Local Stock Factor 2	Regional Stock Factor 1
1	65.15***	10.29***	33.91***	24.03***	60.56***
2	123.62***	5.48***	26.50***	14.04***	39.86***
4	63.34***	27.13***	19.19***	16.35***	23.63***
8	37.14***	13.75***	17.98***	9.72***	19.73***
12	26.19***	13.66***	12.41***	10.24***	13.54***

Notes: The null hypothesis of that there is no ARCH structure in the factors which are derived from the PCA. *** - indicates statistical significance at the 1% level.

Table 11: Historical Integration Scores for Public Real Estate Market Groups

Period	RE1A	RE1B	RE1C	RE2A	RE2B	RE2C
1992	0.3343	0.0053	0.2373	0.2273	0.1185	0.5285
1993	0.3176	0.0182	0.1732	0.1932	0.1343	0.5682
1994	0.2960	0.0100	0.1743	0.1535	0.1516	0.6589
1995	0.3183	0.0035	0.2309	0.1326	0.1395	0.6875
1996	0.2543	0.0138	0.1615	0.1514	0.1140	0.6152
1997	0.2264	0.0066	0.1940	0.1461	0.0859	0.5323
1998	0.1402	0.0046	0.2089	0.1545	0.0892	0.4463
1999	0.1089	0.0103	0.1932	0.1686	0.0907	0.4234
2000	0.0968	0.0095	0.1988	0.1740	0.0931	0.4275
2001	0.1181	0.0088	0.1880	0.1975	0.0959	0.4088
2002	0.0998	0.0124	0.1607	0.2257	0.1037	0.3847
2003	0.0926	0.0154	0.1552	0.2343	0.1058	0.3821
2004	0.0975	0.0214	0.1518	0.2349	0.1049	0.3776
2005	0.1026	0.0203	0.1493	0.2340	0.1064	0.3792
2006	0.1214	0.0246	0.1470	0.2304	0.1034	0.3821
2007	0.1510	0.0255	0.1299	0.2240	0.1003	0.3795
2008	0.2922	0.0219	0.1153	0.2532	0.0983	0.3618
2009	0.3291	0.0230	0.1044	0.2599	0.0931	0.3657
2010	0.3382	0.0231	0.1082	0.2630	0.0919	0.3745

Notes: RE1A (global integration scores for real estate factor 1); RE2A (global integration scores for real estate factor 2); RE1B (regional integration scores for real estate factor 1); RE2B (regional integration scores for real estate factor 2); RE1C (local integration scores for real estate factor 1); RE2C (local integration scores for real estate factor 2); Factor 1 and factor 2 are derived from the PCA (see also Table 9).

Figures

Figure 1: Total Return Index Movement (USD): Public Real Estate, Local Stock, Regional Stock, and Global Stock Market from January 1990 to January 2011

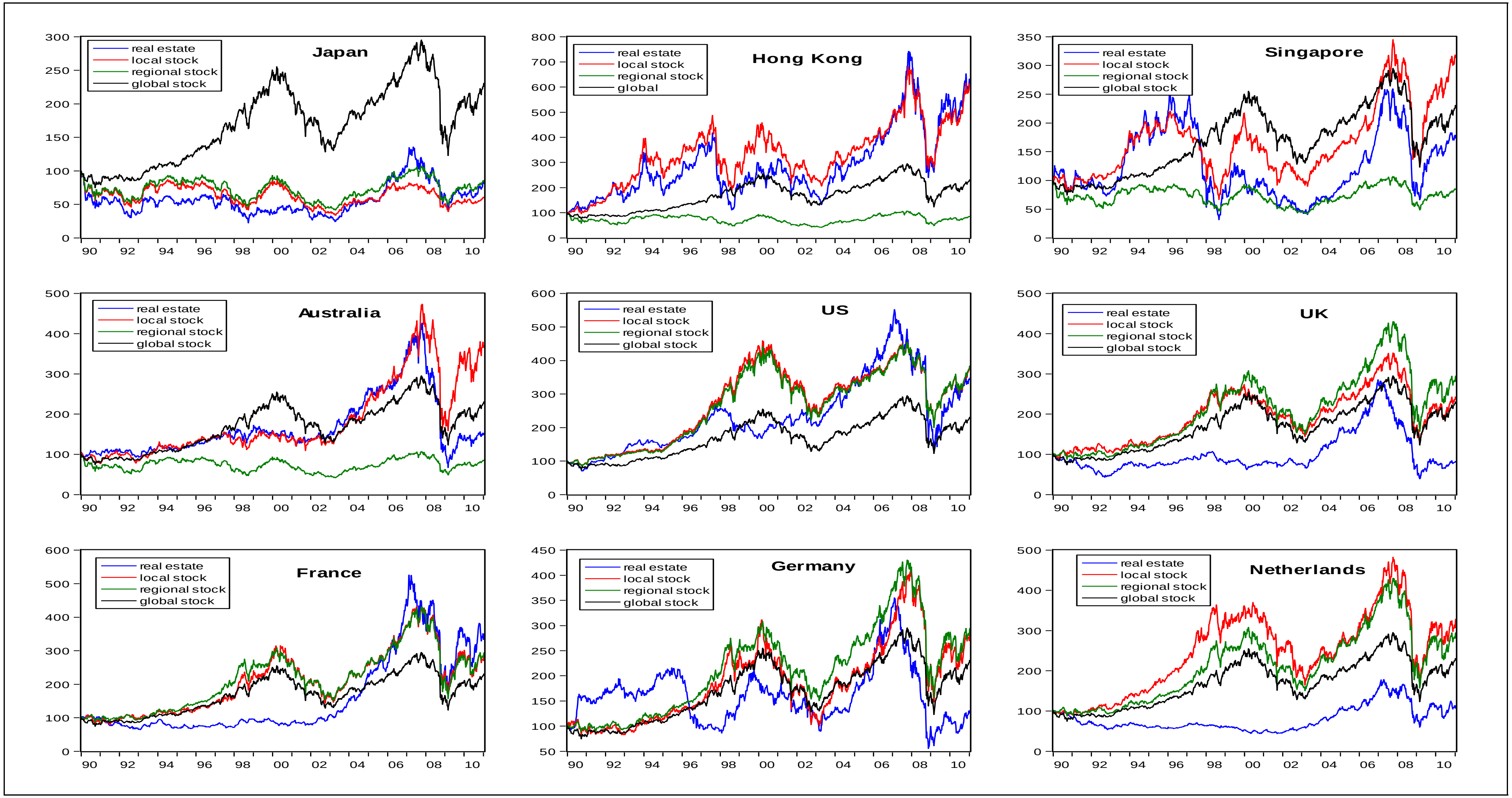


Figure 2: Public Real Estate as a Percentage of the Local Stock Market Capitalization from January 1990 to January 2011

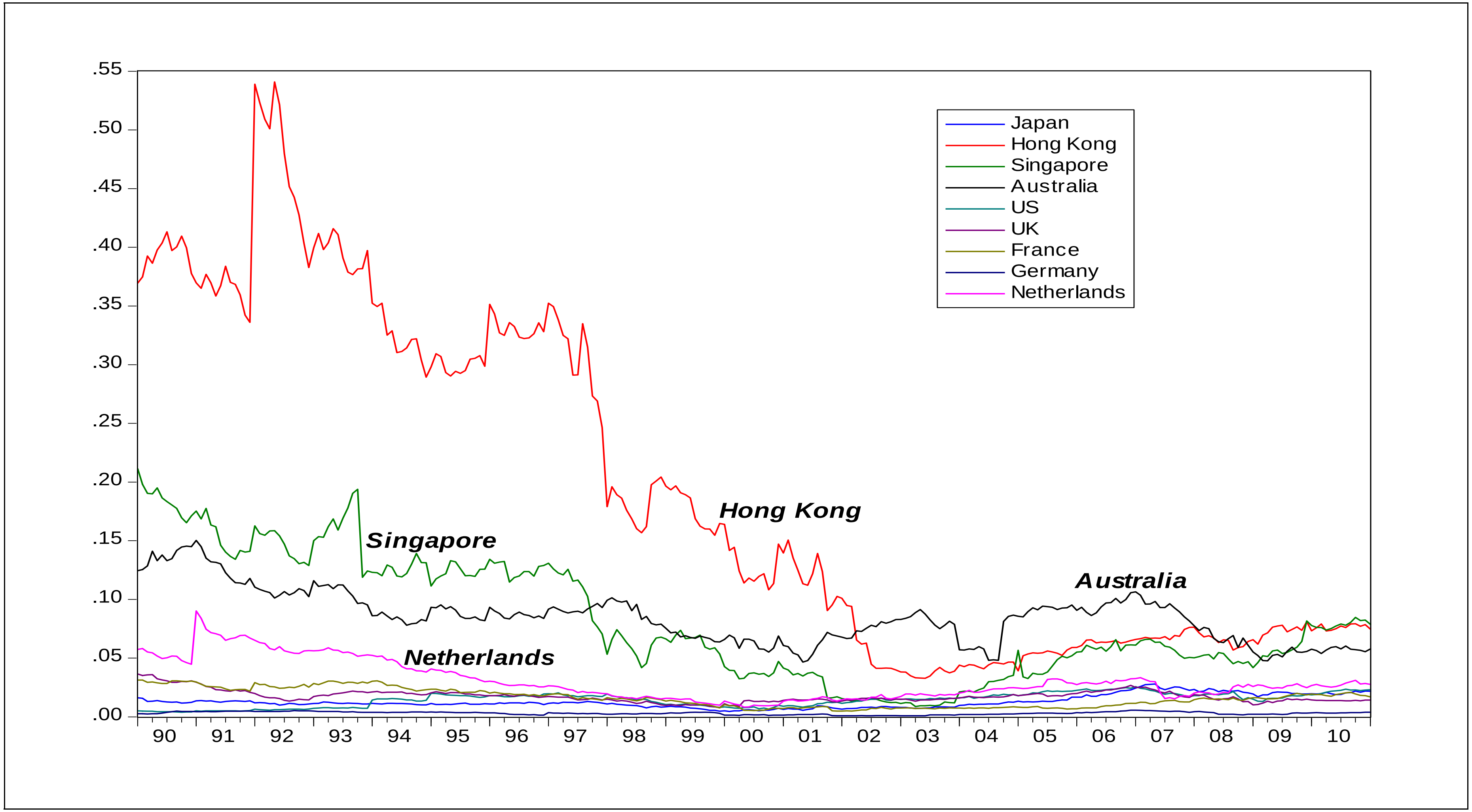


Figure 3: Time-Varying Conditional Correlation between Securitized Real Estate and Stock Markets (Local, Regional and Global)

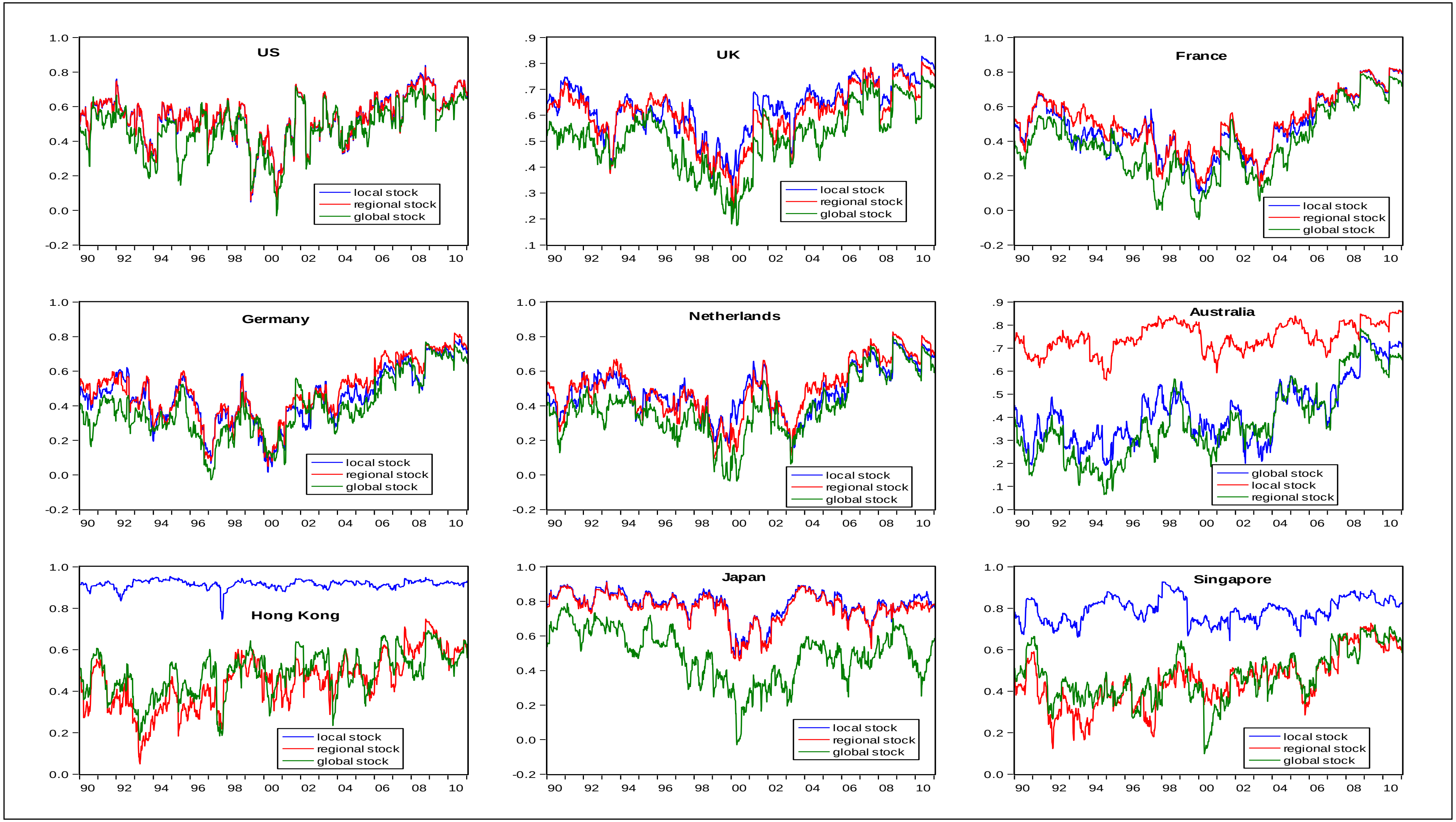


Figure 4: Historical Integration Scores

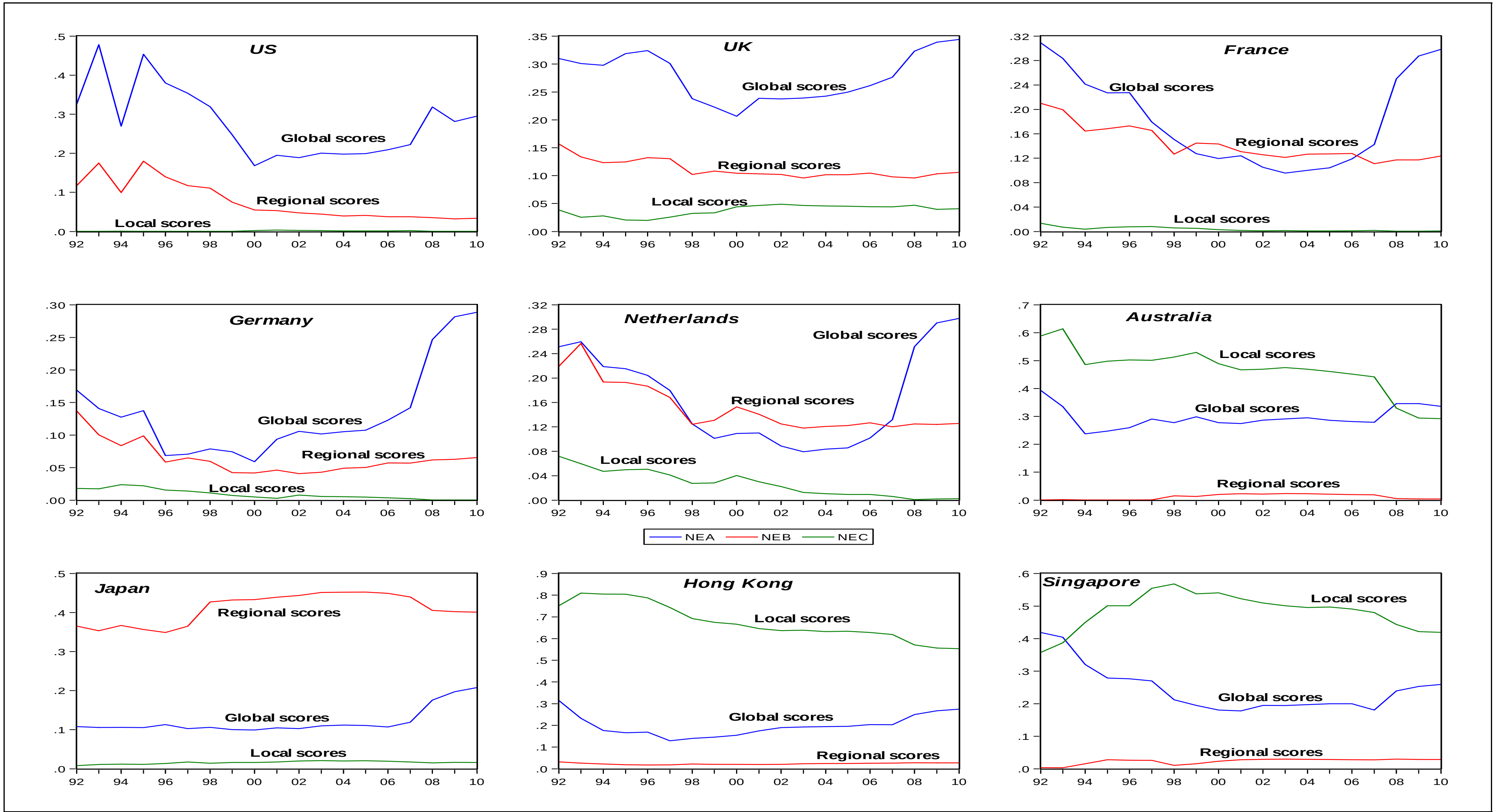
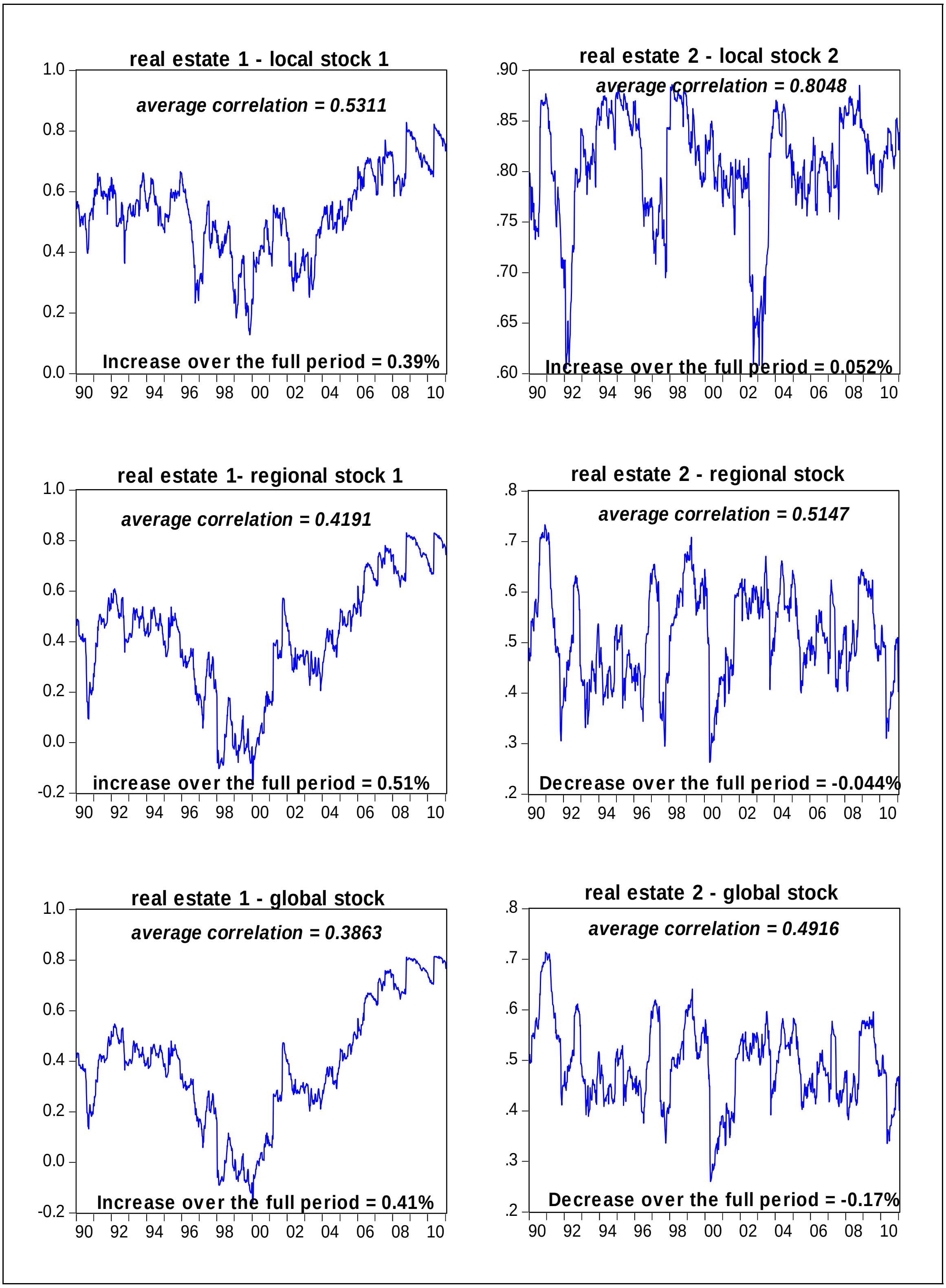
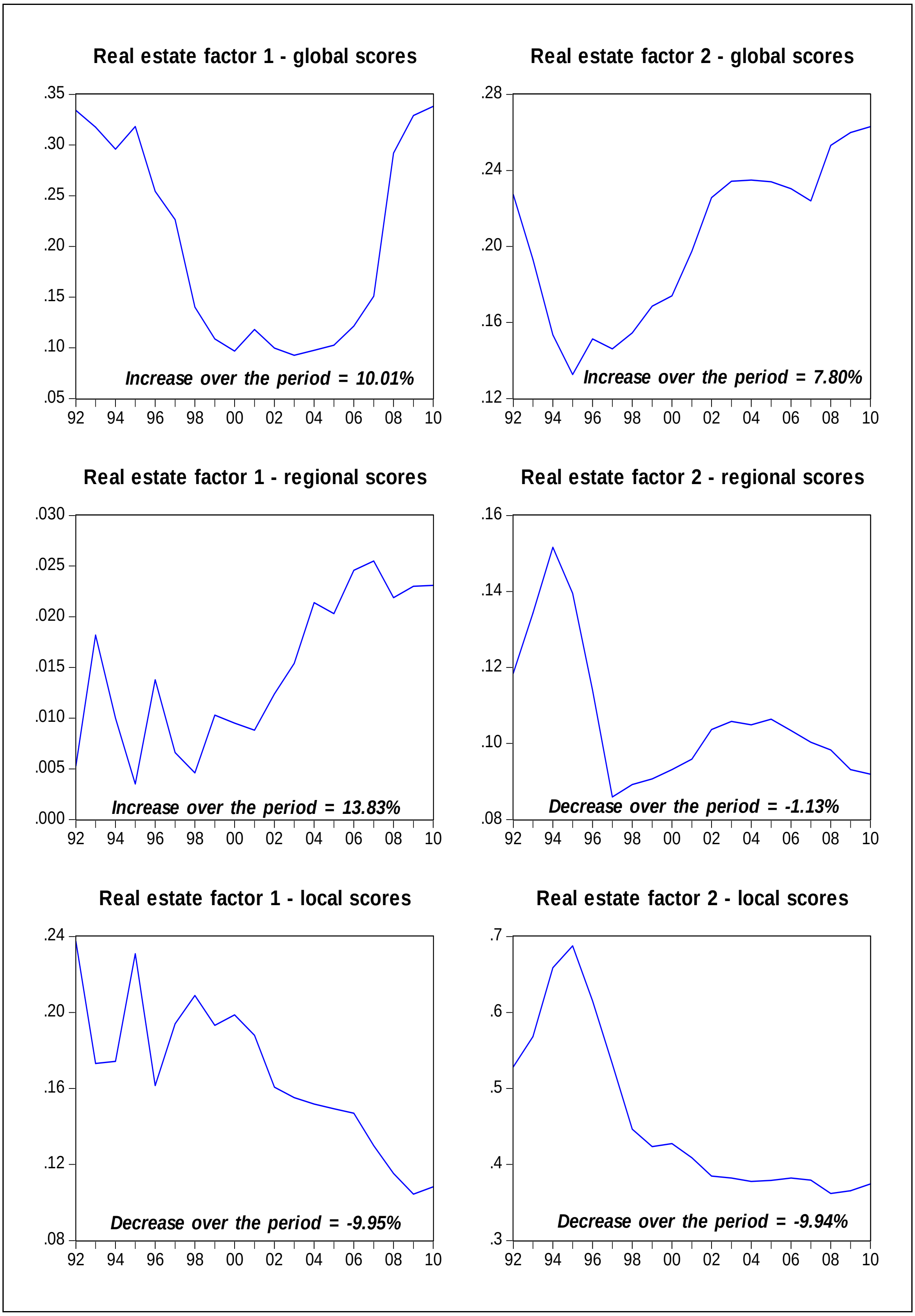


Figure 5: **Time-Varying Dynamic Conditional Correlations between Real Estate Factors and Local Stock Factors, the Regional Stock Factor, as well as the Global Stock Factor**



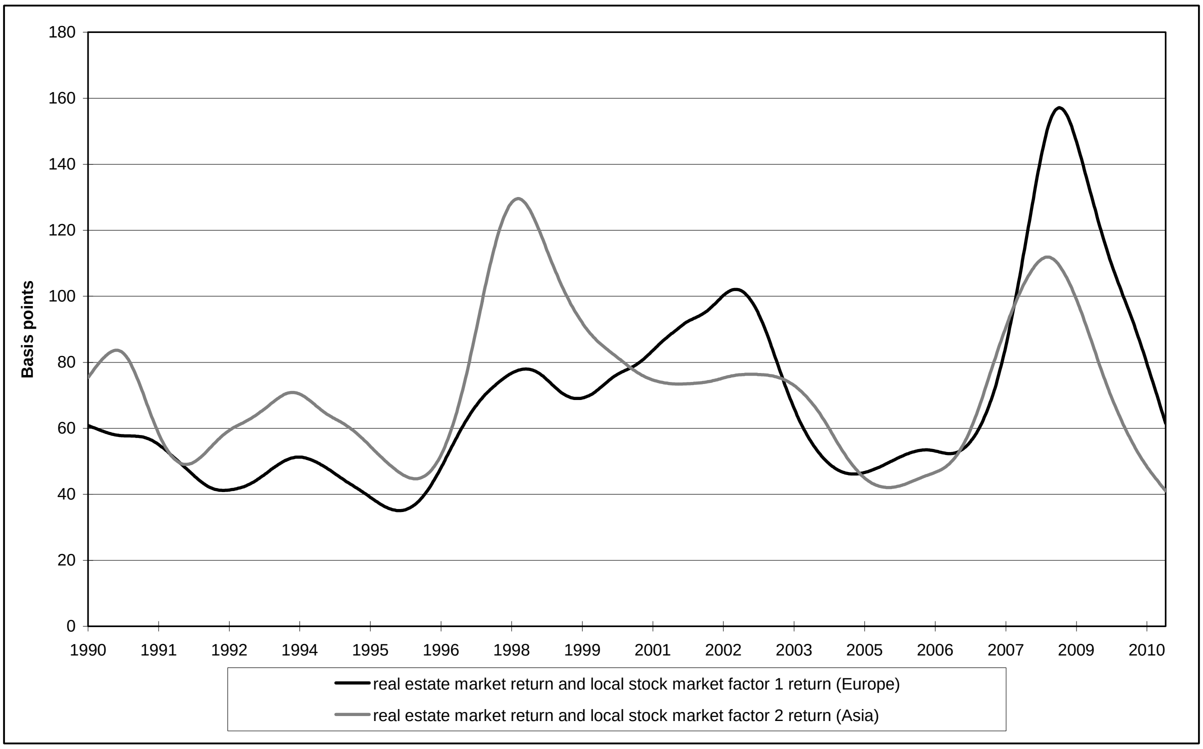
Notes: Following from the PCA analysis, there are two real estate factors, two local stock factors and one regional factor.

Figure 6: Group Results (Real Estate – Stock): Historical Integration Scores



Notes: Based on the factor analysis we examine the real estate-stock integration scores for the nine economies in two groups: (a) Group 1: real estate factor 1 = f (local stock factor 1, regional stock factor, global stock); (b) Group 2: real estate factor 2 = f (local stock factor 1, regional stock factor, global stock). The increase / decrease over the period (January 1991 – January 2011) is estimated via a linear time trend coefficient: $Score_j = \alpha_j + \beta_j \cdot T + \varepsilon_j$, where ε is an error term; % change increase / decrease over the full period = $\beta \cdot 21$.

Figure 7a: Hodrick-Prescott Filtered Return Dispersion: Between Real Estate and Local Stock Factor 1 and Between Real Estate and Local Stock Factor 2



Notes: Local stock factor 1 and local stock factor 2 are derived from the Principal Component Analysis (PCA) (Section 5.4) and are used as two average local stock return benchmarks. The series of return dispersion is calculated as the cross-asset market standard deviation of the weekly returns between the four European real estate securities markets (UK, France, Germany and Netherlands) and the local stock factor1, as well as between the four Asia-Pacific real estate securities markets (Australia, Japan, Hong Kong and Singapore) and local stock factor 2. The two series are filtered using the Hodrick-Prescott smoothing technique to derive the long term trend component of the series.

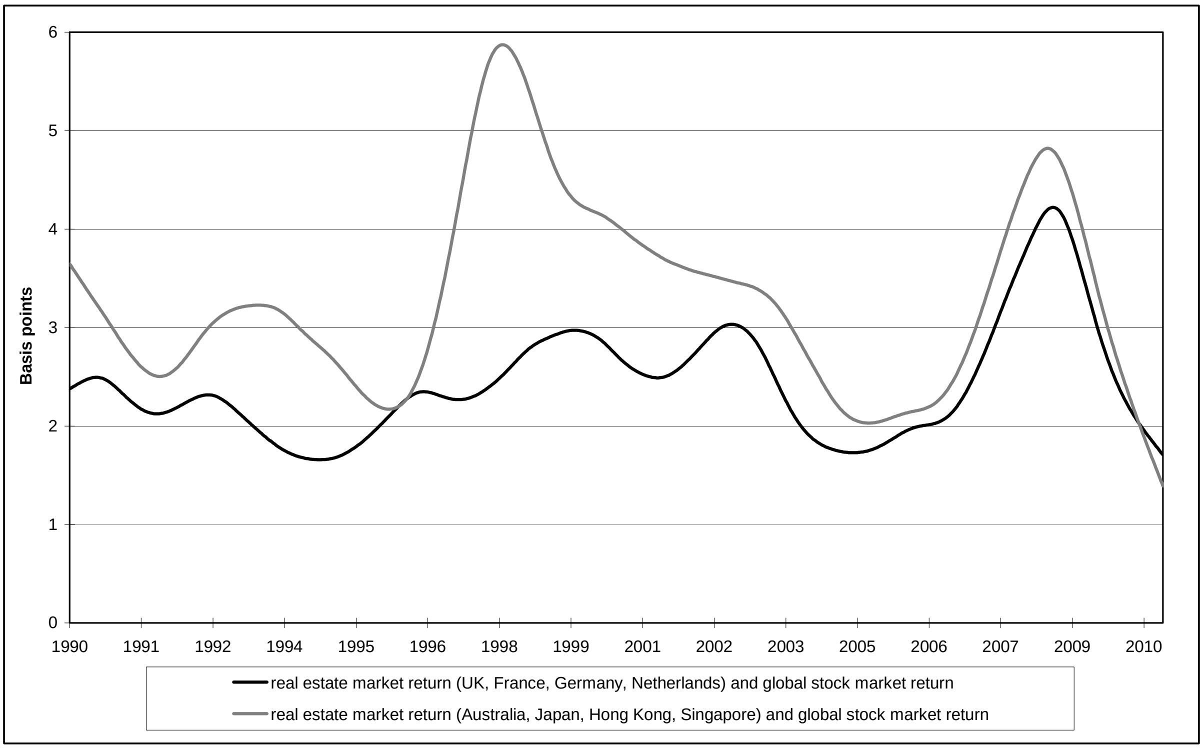
Source: Authors' estimates.

Figure 7b: Hodrick-Prescott Filtered Return Dispersion: Between Real Estate and Regional Stock Market Factors

Notes: Two regional stock factors are derived from the Principal Component Analysis (PCA) (Section 5.4) and used as the average regional stock return benchmarks (factor 1: European; factro2: Asia-Pacific). The series of return dispersion is calculated as the cross-asset market standard deviation of the weekly returns between the four European real estate securities markets and regional stock market factor1, as well as between the four Asia-Pacific real estate securities markets and regional stock market factor 2. The two series are filtered using the Hodrick-Prescott smoothing technique to derive the long term trend component of the series.

Source: Authors' estimates.

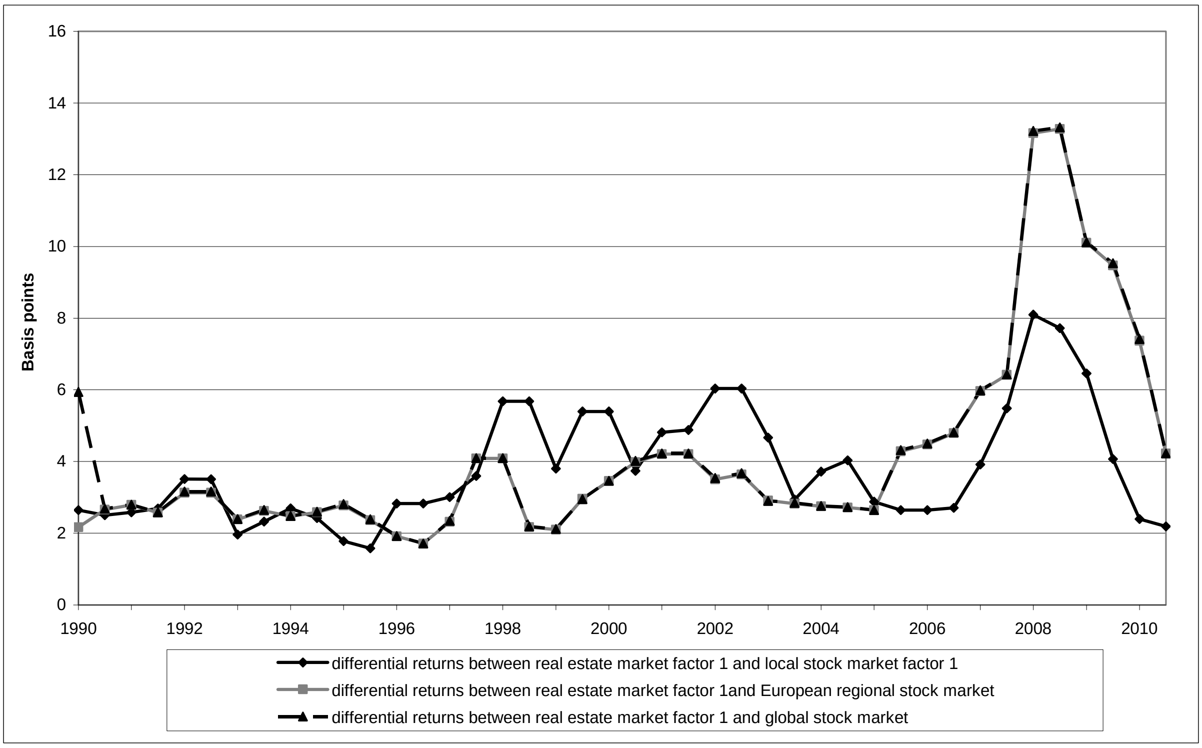
Figure 7c: Hodrick-Prescott Filtered Return Dispersion: Between Real Estate and Global Stock Market



Notes: The series of return dispersion is calculated as the cross-asset market standard deviation of the weekly returns between the four European real estate securities markets and the global stock market, as well as between the four Asia-Pacific real estate securities markets and the global stock market factor 2. The two series are filtered using the Hodrick-Prescott smoothing technique to derive the long term trend component of the series.

Source: Authors' estimates.

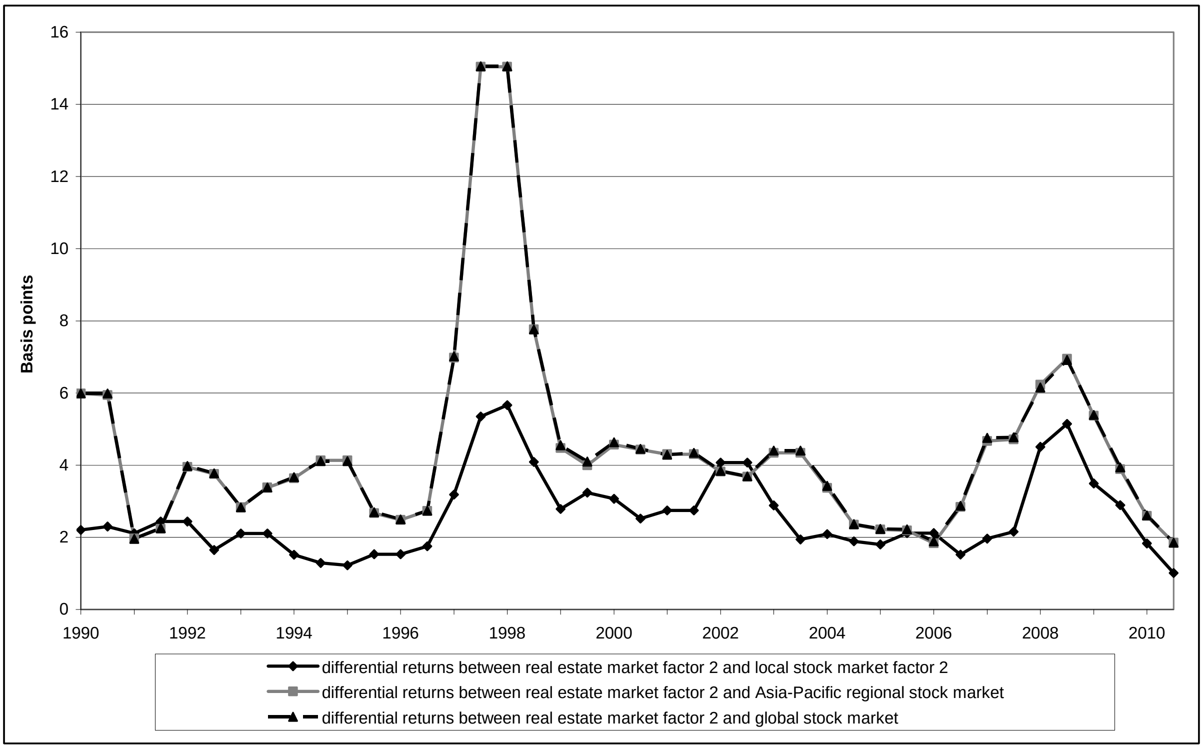
Figure 8a: Rolling Average of Maximum-Minimum Real Estate-Stock Return Differentials in Four European Economies



Notes: For the four European economies, three return series of "real estate-stock" are derived: (a) differential returns between real estate market factor 1 and local stock market factor 1, (b) differential returns between real estate market factor 1 and European regional stock market, and (c) differential returns between real estate factor 1 and global stock market. A 12-month fixed period with 6-month rolling average of the cross "real estate-stock" maximum-minimum return differential, which indicates the dispersion of returns across real estate-stock markets, is calculated.

Source: Authors' estimates.

Figure 8b: Rolling Average of Maximum-Minimum Real Estate-Stock Return Differentials in Four Asia-Pacific Economies



Notes: For the four Asia-Pacific economies, three return series of "real estate-stock" are derived: (a) differential returns between real estate market factor 2 and local stock market factor 2, (b) differential returns between real estate market factor 2 and European regional stock market, and (c) differential returns between real estate factor 2 and global stock market. A 12-month fixed period with 6-month rolling average of the cross "real estate-stock" maximum-minimum return differential, which indicates the dispersion of returns across real estate-stock markets, is calculated.

Source: Authors' estimates.