LONG-TERM BENEFITS FROM INVESTING IN ASIA-PACIFIC REAL ESTATE

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ABSTRACT

This paper analyses long- and short-term co-movements between Asia-Pacific real estate markets and the real estate markets in the U.K. and the U.S. based on bivariate testing for cointegration and correlation analysis. The results indicate that there exist strong long-term relationships between Asia-Pacific real estate markets, while investors located in Asia would benefit from broadening their investment horizon to Australia, Europe, and the U.S. For international investors from the U.S. and the U.K., there exist long-term opportunities to diversify across the Asia-Pacific real estate markets.

Keywords: Cointegration, correlation analysis, diversification, securitized Asia-Pacific real estate

INTRODUCTION

Over the last two decades, real estate attracted investors worldwide and became a fast growing asset class; securitized real estate in particular. This trend was accompanied by the introduction of REIT legislation in several Asia-Pacific countries like Singapore (1999), Japan (2000), Hong Kong (2003), Malaysia (2005), New Zealand (2007), and Philippines (pending in Congress).[1] Other countries like the U.S. and Australia have had this type of legislation or an equivalent one for a long time and represent the leading securitized real estate markets according to their market capitalization related to their GDP.

While the stock and bond markets became more integrated in the last decades, benefits from diversification across international stock and bond markets became smaller, both in the long- and in the short-term. These stronger linkages between international stock markets prompted investors to search for different opportunities to diversify their portfolio. Beside investments in raw materials like oil, precious and industrial metals, international real estate investments show low correlation with stocks and bonds and therefore, have appropriate characteristics contributing to portfolio optimization.

[1] See EPRA (2008) and Ooi et al. (2006).

In the relevant literature, however, it is well documented that asset allocation is home biased by investors and therefore available diversification benefits are eliminated. This argument is even more relevant for real estate investments, since property companies operate mainly in their domestic markets. Therefore, these companies are exposed to domestic economic and political shocks and thus, their business is more influenced by local shocks than the business of internationally operating companies in other sectors like e.g. automobile or pharmaceuticals. On the other hand, these considerations raise the question on how domestic Asia-Pacific real estate investors can benefit from broadening their investment horizon to neighbouring markets and other continents. Second, international investors are interested in the opportunities offered by Asia-Pacific real estate markets and their long- and short-term co-movements between their domestic real estate markets and the Asia-Pacific ones. These two major concerns present the main points of this study. In previous research, the main focus regarding benefits from diversification across real estate markets was mainly on the U.S. and European markets. Even though Asia-Pacific real estate markets have experienced fast growth and the number of listed property companies increased rapidly in the last decade, there have been very few studies on their contribution to diversification benefits. The investment opportunities in the Asia-Pacific real estate markets from the international investors' perspective increased dramatically and the institutional framework supports this tendency with fewer trade barriers, open markets and by introducing the REIT legislation according to the U.S. REIT framework.

In the relevant literature, the main examinations of benefits from diversification and portfolio optimization are based on correlation analysis. However, this concept is associated with some crucial points resulting in strong limitations on its meaning. First, from a technical point of view, the returns have to be normally distributed when applying correlation analysis and portfolio optimization based on the mean-variance-approach by Markowitz (1952). But as shown by Brounen et al. (2008), Liow and Sim (2006), and Liow (2007), this assumption does not hold for real estate returns and Asian real estate stock market returns, in particular. Thus, the concept of portfolio optimization based on the first two moments of a return distribution is not sufficient and investors' preference towards skewness and kurtosis have to be regarded or a different concept has to be applied. Second, correlation coefficients capture only the short-term dependence between asset returns, even though investors are usually interested in long-term interrelation and linkages between prices where cointegration analysis focuses on. Third, correlation analysis is combined with a loss of valuable information contained in time series, since correlation coefficients have to be based on stationary variables and price indices are not stationary commonly. Hence, first differences or logarithmic returns respectively, have to be used together with information on the level of the price series as this is valuable information for the long-term oriented investors. Fourth, in contrast to correlation analysis, the framework of cointegration analysis allows for an estimation of stable long-term relationships in conjunction with (stabilizing) short-term adjustment processes. Thus, it is more appropriate to investigate the cointegration of prices rather than the correlation of returns with regards to the long-term oriented investor.

Due to these shortcomings of correlation analysis, the paper concentrates on long-term benefits from diversification across Asia-Pacific markets by applying cointegration methodology as suggested by Engle and Granger (1987). The implications of cointegration analysis on portfolio diversification depend on the type of investor assumed. Long-run oriented investors with a passive investment strategy realize their highest utility by diversifying across non-cointegrated markets as these markets share no common price trend and have no significant linkage between each other. Contrary to this investor type, investors following an active investment approach focus on cointegrated markets and on the modelling of the short-term error correction model to exploit these adjustment processes for excess return. Thus, the concept of cointegration possesses its relevance for different types of investors. When comparing correlation analysis and cointegration methodology, it is worth emphasizing that these two concepts are not redundant, but complementary and supportive of each other.

The objectives of this paper differ substantially from previous research on the benefits from diversification by investing in Asia-Pacific real estate stock markets:

1. Additional to basic correlation analysis and due to its shortcomings, bi- and multivariate cointegration analysis is conducted for evaluating potential benefits from diversification while previous research investigates basic correlation patterns only.

2. It is shown by applying stability tests suggested by Jennrich (1970) that correlation matrices suffer from instability over time while previous research is mainly focusing on pairwise correlation coefficients or does not statistically test the stability of correlation at all.

3. To our knowledge, it is the first comprehensive study on Asia-Pacific real estate markets considering not only the period of the Asia financial crisis around 1997 and 1998 but also the period of the still ongoing current global financial crises.

4. The nine national real estate indices are delivered by the same index provider (General Property Research) ensuring consistency in index construction and criteria. Thus, the results should not be influenced by potential differences between index construction and index criteria when using different index providers.

The remainder of the paper is laid out as follows. Section 2 gives a review of previous work on diversification benefits from investing in international real estate stock markets and Asia-Pacific real estate stock markets in particular. Section 3 briefly discusses the methodology of testing long- and short-term real estate market interdependence. After discussing the data in section 4, the empirical findings are presented in section 5, while

section 6 summarizes the central results and draws some concluding remarks.

LITERATURE REVIEW

While numerous empirical studies have examined long-term relationships between international stock markets and international bond markets, little research has been done on international real estate markets and Asia-Pacific real estate markets in particular. The main literature contributing to real estate stock markets and its diversification benefits is focusing on mixed-asset allocations in the U.S. or from the viewpoint of U.S. investors. However, little research has been conducted on long-term benefits from investing in international real estate markets.

A comprehensive summary of former research on diversification benefits in a mixed-asset portfolio context and a real estate-only context is provided by Sirmans and Worzala (2003) and Worzala and Sirmans (2003), but most of the studies are for the U.S. market again. Furthermore, conclusions are mainly drawn from correlation analysis without considering time-dependent structures in correlations. More recent studies on diversification benefits from real estate in a mixed-asset context are conducted by Lee (2005) and Cheng and Roulac (2007) for the direct real estate market in the U.S. Both examinations provide diversification opportunities from investing in direct real estate based on correlation analysis, but dynamic, time-varying correlation structures are not analyzed. Lee and Stevenson (2005) also find low correlation between U.S. securitized real estate, U.S. stocks, U.S. bonds, and international stock markets, emphasizing the attractiveness of REITs in the context of a mixed-asset portfolio. The provided diversification benefits increase over longer holding periods supporting the analysis of long-term benefits and diversification opportunities.[2] Waggle and Agrrawal (2006) are concluding as well that securitized real estate should have contributed a substantial part to optimal asset allocations for the U.S., but they confirm that diversification opportunities are time-varying due to unstable correlations between real estate and U.S. stocks. Similar results are found by Brounen and Eichholtz (2003) for mixed-asset allocations both in the U.K. and the U.S. and by Steinert and Crowe (2001) for the U.S.

In addition, Steinert and Crowe (2001) give an outlook on potential diversification opportunities from extending the investment horizon to international real estate. Applying a multi-factor and multi-country model, Bond et al. (2003) find strong local market risk factors attesting the adequacy of international portfolio diversification for U.S. real estate investors. Furthermore, Bond et al. (2003) conclude that diversification is likely to be more effective in Asia-Pacific markets than in European markets. The hypothesis of improved risk-return characteristics from international real estate

[2] In contrast to Lee and Stevenson (2005), Fugazza et al. (2009) cast doubt on the value of time diversification in real estate investments. However, a different technical framework is applied. Nevertheless, Fugazza et al. (2008 and 2009) attest that Equity REITs may considerably improve portfolio performance measured by Sharpe ratio and that correlation structures are time-varying.

diversification is intensively analyzed and confirmed by Conover et al. (2002) and Idzorek et al. (2007) extending U.S. mixed-asset portfolios by international real estate stocks from Asia and Europe. Conover et al. (2002) find correlation between international real estate stocks and U.S. stocks that are much lower than correlations between international and U.S. stocks. This result is shown to be stable through time. Thus, international real estate has a significant weight in efficient international portfolios and improves risk-return-characteristics for U.S. investors. Liow et al. (2009) focus on conditional correlations and confirm lower correlations between international real estate markets than those between common stock markets. Based on CAPM- and Black-Litterman-based forward looking asset allocation, Idzorek et al. (2007) confirm dramatic risk-adjusted performance improvements including North American real estate in the opportunity set. However, this result does not hold for European and Asian real estate in the past, contradicting previous findings. Furthermore, an explicit analysis of time-varying correlation structures and thus, time-dependent diversification benefits is not conducted in the studies by Conover et al. (2002) and Idzorek et al. (2007).

With respect to the European real estate markets, Yang et al. (2005) show that the German, French, and Dutch real estate market became more integrated with other European markets in the post-European-Monetary-Union (EMU) period. However, increased integration in the post-EMU period can not be observed for other EMU markets like Belgium, Italy, and Spain. These results confirm the long-term benefits from diversifying internationally for European real estate markets as well. Fugazza et al. (2007) extend the analysis to a mixed-asset framework and find evidence that European real estate ought to play a significant role in optimal asset allocation for the long-run.

For the Asia-Pacific markets relevant recent literature on the topic of diversification benefits from international real estate investments is conducted by Jin et al. (2007), Liow (2007), Yat-Hung et al. (2008), and Liow and Adair (2009) among others. Both Jin et al. (2007) and Liow (2007) emphasize the increased importance of Asian real estate for both local and international investors. However, Liow (2007) documents as well, that market volatility and international real estate security market betas are time-varying, approving that portfolio analysis based on constant correlations is not adequate. The results by Yat-Hung et al. (2008) match with the results by Liow (2007) and document time-varying correlation structures in a mixed-asset context for the Asia-Pacific markets in Australia, Japan, and Singapore. Liow and Adair (2009) focus on 13 Asia-Pacific real estate markets and the markets in the U.S. and the U.K. Based on correlation analysis, diversification benefits are analyzed in the context of mixed-asset portfolios and real estate-only portfolios as well. The results on Asian mixed-asset portfolio analysis are inconsistent with those for Australia, the U.S. and the U.K. While real estate stocks have a significant weight in efficient portfolios for the latter markets, Asian real estate stocks do not add value to Asian mixed-asset portfolios with the exception of Korea. Considering real estate-only portfolios, Liow and Adair (2009) show that diversification into Asia-Pacific real estate securities can provide positive portfolio implications for

international investors from the U.S. and the U.K. Unfortunately, potential time-varying diversification benefits from investing in Asia-Pacific real estate markets are not considered.

A study by Garvey et al. (2001) focusing on the four Asia-Pacific markets (Australia, Hong Kong, Japan, and Singapore) documents limited evidence of cointegration between the four markets applying cointegration methodology suggested by Engle and Ganger and by Johansen as well. Additionally, Garvey et al. (2001) show statistically significant performance improvements from extending national real estate stock portfolios into other Asian-Pacific markets. These findings indicate that significant long-term diversification gains can be realized by diversifying real estate portfolios throughout Asia-Pacific markets. However, the study considers four markets only and does not include non-Asia-Pacific markets like the U.S. or the U.K. The analyzed period from 1975 to 2001 is also a period where securitized real estate markets were mostly undeveloped or at an early state of market development.

In conjunction with the findings by Liow and Adair (2009) based on correlation analysis and the statement by Ooi and Liow (2004), that their findings "suggest a bright prospect for REIT stocks in East Asia"[3] the following analysis is extending the study by Garvey et al. (2001) to a broader geographical area including further Asia-Pacific markets, the U.S. and the U.K. as well. The study adds to Liow and Adair (2009) by focusing on different time periods and applying different methodology.

In summary, previous research is mainly concentrating on the characteristics of real estate as an asset class and thus, mixed-asset portfolio analysis. However, the vast majority of existing literature confirms that real estate investors ought to expand their perspective from domestic to international markets for exploiting additional diversification benefits. On the other hand, there is still limited research on the linkages between national real estate markets, the optimal allocation of a real estate portfolio, and long-term benefits from diversification among international real estate markets and Asia-Pacific markets, in particular. Thus, the objective of this paper consists of partly fulfilling this gap and showing which markets might be anchor markets suitable for investments.

METHODOLOGY

In the following, the two-stage cointegration methodology presented by Engle and Granger (1987) is mainly employed, whereas the multivariate cointegration test developed by Johansen (1988) is conducted as a robustness check on the validity on the findings by bivariate cointegration only, because the analysis of each individual long-term relationship between two markets enables us to draw some conclusions on building

[3] Ooi and Liow (2004), p. 392.

up real estate portfolios and keeps the analogy with the concept of bivariate correlation coefficients.

In the first step, stationarity conditions of the time series are determined by applying Augmented Dickey-Fuller t-tests (ADF) based on a random walk, a random walk with drift, and a random walk with drift and trend, respectively.[4]

In the next step, by applying the procedure suggested by Engle and Granger (1987), the null hypothesis of no cointegration is tested against the alternative of cointegration. First, the two nonstationary time series Y_{1t} and Y_{2t} are regressed on each other to obtain the residuals from ordinary least square regression:

$$Y_{2t} = \alpha + \beta\, Y_{1t} + \varepsilon_t \qquad (1)$$

Thereafter, these residuals ε_t are tested for unit root characteristics by employing the ADF-test again. Since the residuals are no observed values, but estimated from the OLS regression, the estimated critical values K for the test statistic according to MacKinnon (1991) are applied. Technically, the two time series are said to be cointegrated, if they are integrated of the same order and the residuals from the OLS regression are stationary in levels and integrated of order zero respectively.

According to the Granger representation theorem, if two time series are cointegrated, an error correction model (ECM) can be specified, delivering further insight into the linkage between the two time series and their co-movement over time. The estimation is based on stationary time series and thus, the logarithmic return series are used:

$$\Delta Y_{1t} = \gamma_1 + \lambda_1 \cdot \varepsilon_{t-1} + \sum_{i=1}^{m} \alpha_{11}(i) \cdot \Delta Y_{1t-i} + \sum_{j=1}^{n} \alpha_{12}(j) \cdot \Delta Y_{2t-j} + u_{1t} \qquad (2)$$

$$\Delta Y_{2t} = \gamma_2 + \lambda_2 \cdot \varepsilon_{t-1} + \sum_{i=1}^{m} \alpha_{21}(i) \cdot \Delta Y_{1t-i} + \sum_{j=1}^{n} \alpha_{22}(j) \cdot \Delta Y_{2t-j} + u_{2t} \qquad (3)$$

where γ_1 and γ_2 are coefficients of the constant, $\varepsilon_{t-1} = Y_{2t-1} - \alpha - \beta\, Y_{1t-1}$ from equation (1), and α_{11}, α_{12}, α_{21}, and α_{22} represent coefficients measuring the impact of the lagged returns on the current return of series Y_{1t} and Y_{2t} respectively. The coefficients λ_1 and λ_2 are mainly describing the error correction process.

By implementing lagged returns in the ECM, the short-term relationship and linkages between time series are detected. Additionally, by adding the stationary residuals from the cointegration equation the adjustment process to the common stochastic trend is

[4] See Dickey and Fuller (1981) and Said and Dickey (1984).

analysed. While ε_{t-1} indicates how far the system drifted apart from the common long-term path of equilibrium, the sign and the magnitude of the coefficients λ_1 and λ_2 from the regression indicate which time series adjusts to the common trend and how fast the adjustment process takes place. If $\lambda_1 > 0$ ($\lambda_2 < 0$) and is significant, then a deviation from the common stochastic trend is at least partially corrected by the series Y_{1t} (Y_{2t}). The higher the absolute value of the coefficients is, the faster the adjustment process takes place.

DATA AND DESCRIPTIVE STATISTICS

The empirical analysis in this paper is based on the monthly indices from General Property Research (GPR) between January 1992 and December 2008. The time series contains 204 monthly data for each market. The study covers the following seven Asia-Pacific markets: Australia (AU), Hong Kong (HK), Japan (JP), Malaysia (MY), New Zealand (NZ), the Philippines (PH) and Singapore (SG). Additionally, the markets from the United Kingdom (U.K.) and the United States (U.S.) are added analysing the linkages between Asia-Pacific markets and the largest markets in Europe and Northern America. Sample statistics are calculated in market values based on local currency to focus on real estate factors and to avoid distortions caused by changes in exchange rates. The real estate indices are calculated in natural logarithms, whereas the monthly rates of return are calculated on the first differences of the logarithmic monthly index levels.

In contrast to the studies by Liow et al. (2005), Liow and Sim (2006), Yat-Hung et al. (2008), and Liow and Adair (2009), the national real estate indices are delivered by the same index provider (GPR) with respect to potential differences between index construction and index criteria when using different index providers. The time span from 1992 to 2008 is given by the availability of data.

Figure 1 and Figure 2 present the logarithms of the level of the indices. As shown, the Asian real estate markets are different in their index levels, but they seem to be characterized by a common trend over time which supports the application of cointegration analysis. It is also evident, that the markets followed a common downward trend in the aftermath of the Asian and Russian crisis in 1997 and 1998, which is even much more extended than the one for the non-Asian markets as depicted in Figure 2. A more common development on the international real estate stock markets is shown in the aftermath of the turmoils at the international financial markets starting in June 2007, when Bear Stearns announced serious problems with their hedge funds, and the following and still ongoing global financial crisis.

Figure 1: Price series of the Asian GPR indices

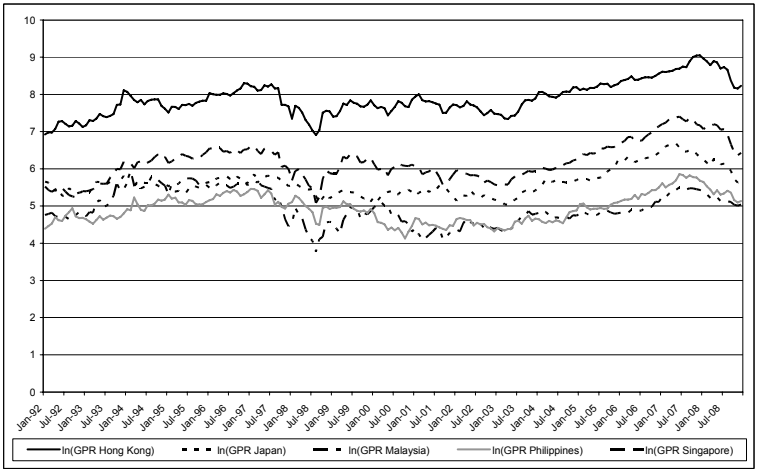

Figure 2: Price series of the Non-Asian GPR indices

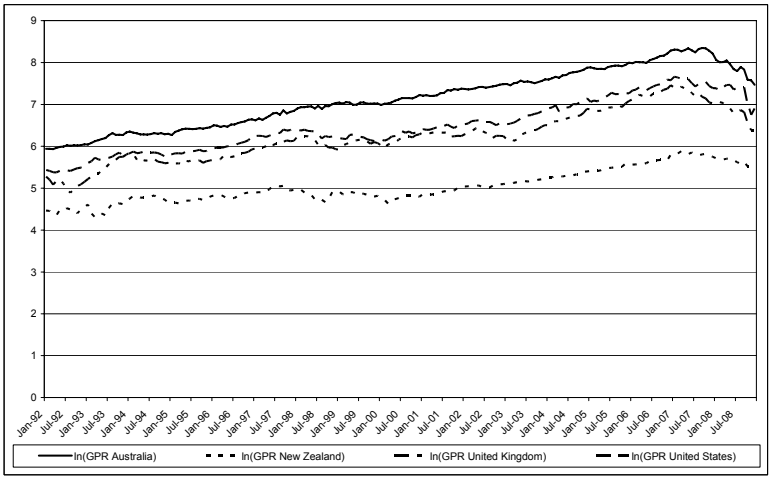

Table 1: Descriptive statistics of the GPR country indices

Index	Mean	S.D.	Skewness (z-stat.)	Kurtosis (z-stat.)	J.-B.
AU	0.0074	0.0403	-1.7145	10.8108	618.5194***
			(10.1449)	(23.7104)	
HK	0.0069	0.1075	0.1328	6.4750	103.2407***
			(0.7856)	(10.5977)	
JP	-0.0006	0.0790	-0.0645	2.9847	0.1437
			(0.3819)	(0.0421)	
MY	0.0012	0.1221	0.1534	4.8441	29.7071***
			(0.9079)	(5.6656)	
NZ	0.0049	0.0447	-0.1844	6.7209	118.8418***
			(1.0910)	(11.3416)	
PH	0.0035	0.1014	0.3140	4.9541	35.8105***
			(1.8581)	(5.9983)	
SG	0.0046	0.1043	-0.2455	6.6111	112.8890***
			(1.4527)	(11.0093)	
U.K.	0.0055	0.0558	-0.9591	4.9615	63.9795***
			(5.6751)	(6.0206)	
U.S.	0.0074	0.0534	-2.7548	19.6537	2,615.4649***
			(16.3004)	(50.4535)	

Notes:
S.D. is the standard deviation of the return distribution of the national real estate stock indices. ***, ** and * indicate the rejection of the null hypothesis of the Jarque-Bera test statistic (J.-B.) for normality at the 1 %-, 5 %- and 10 %-level of significance. The test results of statistical significance from zero, for skewness coefficients, and from three, for the kurtosis coefficients, are reported in parentheses. The critical values for the coefficient test at 1 %-, 5 %-, and 10 %-level of significance are 2.58, 1.96, and 1.65.

For the period under consideration, Table 1 gives an overview of the return and risk characteristics of the nine national real estate stock indices. As can be seen, the performance of the countries' securitized real estate markets is very heterogeneous and differs substantially between national markets. While Australia and the U.S. have an average monthly return of above 0.74 %, the Japanese market has a slightly negative average return around -0.06 % only. Furthermore, the non-Asian markets are characterized by the lowest standard deviations resulting in the highest Sharpe-ratios for the real estate markets in Australia, New Zealand, the U.K., and the U.S. These findings are in line with the results by Liow (2007) and Liow and Adair (2009) and are questioning the benefits from investing in Asian real estate markets. But on the other hand, investors located in Asia could benefit from broadening their investment horizon and investing abroad. But there has to be made one point in defence of the high volatility of the Asian market. The Asian securitized real estate markets are dominated by property developers and construction activities. Therefore, the cash flows of their business and

consequently the equity returns are more volatile in contrast to REITs and other property companies, where rental investments dominate.[5]

Evaluating the attractiveness of markets by their Sharpe ratios solely based on the first and second moment of the return distribution is only reasonable when the observed returns are normally distributed or investors' utility functions are quadratic. However, according to the test statistics of the Jarque-Bera normality test, the null hypothesis of normally distributed returns is rejected for eight out of nine national indices at the 1 %-level of significance.[6] Only the Japanese real estate market has normally distributed returns. The third and fourth moment emphasize these findings. With the exception of the Japanese market, the return distributions are leptokurtic and negative skewness dominates. Due to the results above, the use of standard deviation as a measure of risk may result in distortions of the true performance. The z-values, in parentheses in Table 1, specify whether the deviation from normality is attributed to the third and/or the fourth moment of the return distribution. Using the testing method suggested by Urzúa (1996), the findings indicate that for Australia, the U.K., and the U.S. both higher moments are responsible for the significant non-normality. For all other non-normally distributed indices, kurtosis alone determines the rejection of normality. Thus, low correlation coefficients can be in support of pervasive diversification benefits, but portfolio optimization and investment decisions based on them are of restricted relevance.

EMPIRICAL RESULTS

The presentation of the empirical findings is divided into two parts. First, the correlation structure is considered despite its mentioned limitations. In the second part, the examination focuses on the long-term relationships between the real estate markets and their implications for diversification and investors' investment opportunities.

Correlation analysis

The correlation coefficients between the nine real estate market indices are displayed in Table 2. All correlation coefficients are positive and in a range between 0.08 and 0.50 with two exceptions. Thus, they are very low compared to correlations between common stock markets and indicate pervasive benefits from diversification across national borders and continents. The highest dependencies exist between the two Asian markets in Hong Kong and Singapore and between the markets in the U.K. and the U.S. with correlation coefficients of 0.74 and 0.55 respectively. The low correlations between the Asia-Pacific markets and the markets of the U.K. and the U.S. suggest that investing into Asia-Pacific real estate stock markets enhances portfolio diversification benefits for international investors from the U.K. and the U.S. Furthermore, investors from Asia-Pacific countries gain more pervasive benefits from diversification by expanding their investment horizon

[5] See Newell and Chau (1996), Liow (1997), and Hoesli and Serrano (2008) as well.
[6] See Brounen et al. (2008), Liow (2007), and Liow and Sim (2006) as well.

from their domestic market to the international real estate stock markets than by investing in other Asia-Pacific markets. These findings are supportive of findings of previous studies by Liow et al. (2005), Liow and Sim (2006), and Liow and Adair (2009).

Table 2: Correlation coefficients between the GPR country indices

	AU	HK	JP	MY	NZ	PH	SG	U.K.	U.S.
AU	1.00								
HK	0.28***	1.00							
JP	0.28***	0.15**	1.00						
MY	0.17**	0.44***	0.12*	1.00					
NZ	0.33***	0.24***	0.26***	0.25***	1.00				
PH	0.13*	0.32***	0.17**	0.17**	0.27***	1.00			
SG	0.31***	0.74***	0.26***	0.49***	0.33***	0.40***	1.00		
U.K.	0.42***	0.28***	0.26***	0.22***	0.19***	0.08	0.33***	1.00	
U.S.	0.46***	0.30***	0.31***	0.19***	0.22***	0.13*	0.35***	0.55***	1.00

Notes: ***, ** and * indicate for significance of the correlation coefficient at the 99 %-, 95 %- and 90 %-confidence level.

However, the previous analysis is static and no dynamics over time are considered, challenging the analysis of correlation structure over time. Since rolling correlation and semicorrelation[7] give some evidence that correlations are unstable over time, but do not have any statistical power, a testing method suggested by Jennrich (1970) is conducted. In contrast to classical pairwise correlation tests which are based on average correlation and standard deviation of a correlation matrix, the Jennrich (1970) test is able to take into account the length of the time series on which the correlations are based. The Jennrich test is analyzing the difference between two correlation matrices.

The analysis is based on four equal subperiods of 52 months. The four subperiods are January 1992 through March 1996, April 1996 through June 2000, July 2000 through September 2004, and October 2004 through December 2008. The test statistics tabulated in Table 3 reject the stability of the correlation matrix at conventional significance levels for four out of six comparisons. During the Asia financial crisis, the correlations between the Asian markets sharply increased, while they decreased in the period from 2000 to 2004. In the period from October 2004 to December 2008, the correlation between almost all analyzed markets increased dramatically caused by the global contagion of the financial crisis. These findings of unstable correlation matrices cast further doubt on the evaluation of benefits from diversification by correlation analysis and suggest that correlation analysis and the mean-variance framework are not appropriate for analyzing long-term benefits from diversification.

[7] In the interest of space, rolling correlation and semicorrelation are not presented in this study.

Table 3: Stability of the correlation matrix analyzed by the Jennrich test for nine real estate stock market indices

Periods compared		Jennrich Test Statistic
I	II	
Jan 92 – Mar 96	Apr 96 – Jun 00	60.43**
Jan 92 – Mar 96	Jul 00 – Sep 04	39.06
Jan 92 – Mar 96	Oct 08 – Dec 08	45.67
Apr 96 – Jun 00	Jul 00 – Sep 04	51.69**
Apr 96 – Jun 00	Oct 08 – Dec 08	50.96**
Jul 00 – Sep 04	Oct 08 – Dec 08	58.07**

Notes: ***, ** and * denote the rejection of the null hypothesis of the Jennrich statistic at the 1 %-, 5 %- and 10 %-level of significance. The test statistic is χ^2-distributed with D(D-1)/2 degrees of freedom where D is the dimension of the matrix.

Furthermore, since correlation analysis is only valid for stationary variables, the prices have to be de-trended by calculating first differences. However, this procedure vanishes valuable information about the detection of common trends in prices. While correlation is an appropriate and highly used measure of short-term co-movements, it is not assured by low correlation coefficients that there are low long-term co-movements as well and vice versa. Thus, the further examinations of this paper focus on stable long-term linkages between the price series of the nine real estate indices and the dynamic interactions between these markets.

Unit root test of prices and returns

As described above, stationarity tests are conducted by applying the Augmented Dickey-Fuller (ADF) unit root test to levels and first differences. ADF-values are calculated by estimating regression equations of three types of specification: a random walk (ADF), a random walk with drift (ADF_C), and a random walk with drift and trend (ADF_T), respectively. The relevant literature suggests different procedures to determine the lag length and the ADF-test.

In principle, there exist two ways on how to determine the adequate lag length. In one procedure, the optimal lag length is found by successively adding one additional lag until a significant lag is found. But it is shown by Monte Carlo studies that this procedure is biased in its specification selection. Alternatively, the determination process can be started with a relatively long lag length and the model is pared down until a significant lag is identified as proposed by Ng and Perron (1995) and Enders (2004). In this study, the latter approach is used by starting with a lag length of 10 as the initial value. If the t-statistics are insignificant for all lags at the 10 per cent level of significance, the equations are re-estimated and the results are tested on 20 per cent level. The right ADF-test is chosen by minimizing Akaike information criterion or the Schwarz criterion. Additionally, the testing procedure by Phillips and Perron (1988) is conducted confirming the stationarity of the first differences of logarithmic prices.

As displayed in Table 4, the findings of the unit root tests are consistent for all nine real estate indices. The null hypothesis of a unit root can not be rejected for the logarithmic prices. Thus, the indices are not I (0) at the 1 per cent significance level and not stationary in levels respectively. However, the first differences do not exhibit a unit root at the 1 per cent level and are stationary.

Table 4: Unit root test of prices and returns

Indices	Unit Root Test in ln (prices)			Unit Root Test in Δ ln (prices)			Integration Level
	ADF_T	ADF_C	ADF	ADF_T	ADF_C	ADF	
AU		-1.9025 (10)				-2.7414*** (4)	I (1)
HK	-3.0506 (8)					-3.8412*** (10)	I (1)
JP		-1.6922 (3)				-7.4876*** (2)	I (1)
MY		-2.6726* (9)				-4.0467*** (10)	I (1)
NZ	-2.2859 (1)					-5.3409*** (5)	I (1)
PH		-2.1092 (0)				-11.0716*** (1)	I (1)
SG		-2.4490 (7)				-3.9029*** (10)	I (1)
U.K.			0.3743 (5)			-3.6619*** (4)	I (1)
U.S.		-1.6415 (2)			-10.5493*** (1)		I (1)

Notes: ***, ** and * indicate the rejection of the null hypothesis of a unit root at the 1 %-, 5 %- and 10 %-level of significance. The lag lengths for unit root tests of prices and returns are given in parentheses.

Unit root test for cointegration residuals

Following the results of the unit root tests, all real estate markets are integrated of the same order being essential for estimating cointegration vectors. As described above, the first step of the pairwise cointegration test proposed by Engle and Granger (1987) consists of the estimation of the ordinary least square (OLS) regression of logarithmic real estate market indices. In the second step of the two-stage procedure, the residuals from the OLS regression are subjected to the unit root test. From a theoretical point of view, there should not be a difference in the testimony on cointegration when Y_{2t} is regressed on Y_{1t} instead of the regression of Y_{1t} on Y_{2t}. However, it is documented in the relevant literature that differences emerge when using empirical data. Therefore, 72 regressions are estimated instead of 36 ones. With six exceptions, all slope coefficients are positive. Only the estimations of the regressions between the real estate market of

Malaysia on the one hand and the markets of Australia, the U.K., and the U.S. on the other hand result in negative slope coefficients.

The methodology chosen for the unit root test of the residuals from the OLS regression is equivalent to the one described above with one exception. Instead of using the critical values of MacKinnon (1996), the critical values of MacKinnon (1991) are applied. The rejection of the null hypothesis of a unit root of the residuals indicates that the two time series are cointegrated.

For 14 out of 72 residual series, the null hypothesis of a unit root is rejected by the ADF-test and thus, these real estate markets share a common stochastic trend and are said to be cointegrated. While for four relationships, this result is independent of the endogenous and exogenous variable, the modelling matters for six pairs of real estate markets. Table 5 is summarizing the unit root tests for the cointegrated real estate market indices.

Table 5: Results for bivariate cointegration between real estate markets

Indices		**Unit root tests in regression residuals**	
Endogenous variable	Exogenous variable	ADF_T	ADF_C
HK	JP		-4.8569*** (0)
JP	HK		-4.3921*** (0)
HK	NZ		-3.3509* (10)
NZ	HK	-3.6059* (10)	
HK	SG	-3.6317* (8)	
SG	HK		-3.7516** (1)
NZ	U.S.		-3.2879* (9)
U.S.	NZ		-3.3962** (2)
HK	MY	-3.6621* (0)	
HK	PH	-3.9910** (9)	
JP	SG		-3.7051** (0)
NZ	PH	-3.7826* (0)	
MY	PH	-4.0488** (10)	
SG	PH	-3.9089** (0)	

Notes: Approximate critical values for ADF-tests are based on MacKinnon (1991). ***, ** and * indicate the rejection of the null hypothesis of a unit root at the 1 %-, 5 %- and 10 %-level of significance. The lag lengths for unit root test of the regression residuals are given in parentheses.

While correlation analysis indicates pervasive benefits from diversification, even across Asian real estate markets, the conclusions from cointegration analysis are different. During the period investigated, the long-term interdependence between the five Asian real estate markets is significant. The real estate market in Hong Kong possesses long-term relationships with the other four markets and there exist linkages between the other

markets as well. Thus, the long-term benefits from diversification across Asian real estate markets are limited for long-term oriented investors with passive investment strategies. These results of strong long-run equilibrium relationships among the Asian real estate markets are in contrast to the findings by Liow et al. (2005) stating no cointegrating relationships among the four Asian property stock indices of Hong Kong, Japan, Malaysia, and Singapore. Using Engle-Granger-test for cointegration, Garvey et al. (2001) identify only one long-term relationship between the real estate markets of Australia and Singapore during the period from 1993 to 2001, but no further cointegrating relationship between Australia, Hong Kong, Japan, and Singapore.

In addition to the Engle-Granger (1987) methodology and as a robustness check on the findings resulting from bivariate cointegration analysis, multivariate cointegration tests using the methodology suggested by Johansen (1988) are conducted. In contrast to the Engle-Granger (1987) methodology, this procedure allows the simultaneous estimation of the long-term relationship and the short-term adjustment process using vector error correction models. However, the results from the Johansen procedure are sensitive to the lag length selected. According to the final prediction error and the Akaike information criterion as well, a lag length of one is selected. Both the trace test statistic and the maximum eigenvalue test statistic indicate two cointegration equations at the 5 %-level of significance.[8] These findings are in contrast to Garvey et al. (2001) finding no multivariate cointegration relationship between Australia, Hong Kong, Japan, and Singapore for the period from 1975 to 2001.

In the next step, restrictions on insignificant coefficients in the cointegration and vector error correction equations are imposed. One cointegration relationship consists of Asia-Pacific real estate stock markets with the exception of the Japanese market only. This strong long-term relationship with highly significant coefficients and the corresponding error correction model is in support of the results from bivariate cointegration analysis. Furthermore, the findings confirm limited long-term diversification benefits across Asia-Pacific real estate stocks. The short-term adjustment process is mainly driven by the real estate stock markets of Hong Kong, Malaysia, and the Philippines which is consistent with the findings resulting from bivariate cointegration analysis presented in Table 6. The results from the second cointegration relationship are quite similar to the previous with the exception of the U.S. market. While the U.K. real estate stock market is not contained in any long-term relationship, the U.S. market shows some long-term dependencies with the Asia-Pacific markets from Hong Kong, Japan, Malaysia, and New Zealand, but is not adjusting to the long-term relationship. This short-term adjustment process is mainly driven by the markets from Hong Kong and New Zealand. The results implicate some weak limitations in the long-term potential diversification benefits for U.S. investors which are not detected by analysis based on correlations.

[8] The p-values are calculated as suggested by MacKinnon et al. (1999).

Summarizing the findings from multivariate cointegration analysis, the results reveal limited evidence on diversification benefits among Asia-Pacific real estate stock markets but pervasive benefits for investors from the U.S. and the U.K., in particular, from investing in Asia-Pacific real estate markets and vice versa.[9]

In line with results from correlation analysis and the findings by Liow and Adair (2009) investors located in Asia can benefit from broadening their investment horizon to the U.K., and the U.S. Thus, both bi- and multivariate cointegration analysis give further evidence on Asian investors' benefits from investing in U.K. and U.S. real estate and approve the results from correlation analysis for the long run. There is no evidence of a long-term relationship between the Asian real estate markets and the markets in Australia, the U.K., and the U.S. Only the market in New Zealand is characterized by a long-term relationship to both the U.S. market and the Asian markets. For international investors considering real estate investments in Asia, the market in Hong Kong tends to work as a representative market for the other Asian markets and thus, this market could be an appropriate alternative for an investment in Asia. In contrast to the markets in Malaysia and the Philippines in particular, the market capitalization is much higher in Hong Kong. Furthermore, through its close link to the Chinese market, investors could benefit from China's fast growing economy connected with a booming construction sector and large infrastructure projects as well by investing in Hong Kong's real estate stock market.

Short-term relationship according to the error correction model

While cointegration methodology presents a concept of modelling long-term relationships, nothing is said about the short-term behaviour of cointegrated markets until this point. In general, cointegrated markets share a common stochastic trend, but both markets fluctuate around this common trend and are not exactly on their long-term path at each point of time. From an investors' perspective, it is of interest how and by which market the adjustment takes place when one or both markets moved away from the long-term path of equilibrium. This procedure is often modelled by an error correction model (ECM) indicating the direction and rate of adjustment. In this paper, the analysis is conducted by the ECM-framework presented above. The ECM is estimated by OLS regression with stationary variables including an intercept term, the lagged residuals from the cointegration equation and the lagged returns of both cointegrated markets up to six month as exogenous variables and the actual return as endogenous variable. The model is re-specified until only significant coefficients for the lagged returns are left.

The magnitude and the sign of the regression coefficient of the residuals from cointegration equation are of special interest and indicate the rate and direction of

[9] In the interest of space, the results from multivariate cointegration analysis in conjunction with the vector error correction model are not presented, but are available from the author upon request.

adjustment which is presented in Table 6.[10] The results are not uniform, but mixed. For two cointegration relationships (between Hong Kong and Japan and between Japan and Singapore respectively) the deviation from the common long-term stochastic trend is revised by the impact of both markets. The coefficients have the "right" sign and they are significant. For all the other bivariate relationships among the Asian markets only one market is responding to a deviation, where mainly Hong Kong, Malaysia, and the Philippines drive the adjustment process into a stabilizing direction. The error correction model between the markets of New Zealand and the Philippines does not show significant coefficients and thus no adjustment process can be identified. This is in contrast to the econometric theory of cointegration and errors correction models, because according to theory, each cointegration relationship is accompanied by an ECM and vice versa.[11] The empirical result could be due to difficulties in specifying the lag-structure of the unit root test because the Akaike criterion suggested a different modelling than the Schwarz criterion. Hence, selecting the model with a significant coefficient for lag five results in no stationarity of the residuals and thus, no cointegrating relationship between the real estate markets of New Zealand and the Philippines. The findings for the only inter-continental relationship between New Zealand and the U.S. are straight forward, not surprising, and in line with general theory in finance and economics: The small and low capitalized real estate market of New Zealand is adjusting to the long-term trend between these two markets, while the coefficient with respect to the U.S. market is not significant.

Table 6: Direction and rate of short-term adjustments between cointegrated markets

Indices		**Adjustment coefficient of the ECM for**	
Endogenous variable	Exogenous variable	Endogenous variable	Exogenous variable
HK	JP	-0.0995***	0.0454
JP	HK	-0.0706***	0.0865**
HK	NZ	-0.0915***	-0.0005
NZ	HK	-0.0094	0.0716**
HK	SG	-0.1241***	0.0012
SG	HK	-0.0286	0.0799*
NZ	U.S.	-0.1290***	0.0096
U.S.	NZ	-0.0280	0.0747***
HK	MY	-0.0347*	-0.0088
HK	PH	-0.0484**	0.0261
JP	SG	-0.0564**	0.0633*
NZ	PH	-0.0029	0.0231
MY	PH	-0.0584**	0.0202
SG	PH	-0.0317	0.0482**

Notes: ***, ** and * indicate for significance of the coefficient from OLS regression at the 99 %-, 95 %- and 90 %-confidence level.

[10] With respect to a clear layout the adjustment coefficient is presented only. The model specification is available from the author upon request.

[11] See Engle and Granger (1987 and 1991).

For the investors' type using active trading strategies, the deviations from the stable common long-term trend can be exploited by two ways depending on the market situation. First, when the responding market is above its correct level according to the cointegration relationship, it is attractive to sell this market. On the other hand, when the responding market is below its theoretically expected level, this market should be bought. The analogous thoughts apply when both markets are responding. Then, one market should be bought and the other one should be sold to exploit the deviations from the common equilibrium. Subject to the estimated adjustment coefficients, these effects are highly pronounced for the cointegration relationships and the corresponding ECMs between the real estate markets in Hong Kong and Singapore and the markets in New Zealand and the U.S. respectively. With respect to the extension of the adjustment process, similar effects are exploitable based on the markets of Hong Kong and Japan, where the sum of the two significant coefficients in absolute terms (0.0706 and 0.0865 respectively) adds up to 0.1571 and thus, the effect is higher than for any other specification.

CONCLUSION

In the literature, authors often argue that diversification benefits are driven by country factors and thus broadening the investment horizon from a domestic to a more global perspective improves the mean-variance-characteristics of a portfolio by an upward shift of the efficient frontier. The achievement of these beneficial return-risk-characteristics is often based on a concept by which risk reduction is measured by correlation structures between the returns of different assets or markets. However, correlation analysis is accompanied by some essential limitations, which were discussed above in more detail. First, from a technical point of view, the returns have to be normally distributed when applying portfolio optimization based on correlation analysis. But as also shown above, this assumption does not hold for real estate returns at least. Second, correlation coefficients capture only the short-term dependence between these assets and investors are usually interested in long-term interrelation between prices where cointegration analysis focuses on. Third, correlation analysis is combined with a loss of valuable information contained in the time series, since correlation coefficients have to be based on stationary variables and price indices are not stationary commonly. So, first differences or logarithmic returns respectively, have to be used combined with information on the level of the price series, which is important information for long-run oriented investors. Thus, the investigation of the cointegration of prices rather than the correlation of returns is a more appropriate approach with regards to a long-run oriented investor type.

By using seven Asia-Pacific real estate indices and the indices from both the United Kingdom and the United States as the largest real estate markets in their geographical and economic area, the findings, based on the approach suggested by Engle and Granger (1987), indicate the following main conclusions: First, the analysis shows no evidence

that the securitized real estate market of the United Kingdom, as the representative market for Europe, is cointegrated either with the Asia-Pacific markets or with the U.S. market. Second, the securitized real estate market of the U.S. is not cointegrated with any other market except the one from New Zealand whereas the U.S. market is the leading one and New Zealand is responding. There is no evidence of a long-term relationship among the prices of the Australian market and the other Asia-Pacific markets, but Asian markets have proved to have diverse long-term relationships among themselves. The securitized real estate market of Hong-Kong, in particular, shows strong relationships to all other analyzed real estate markets in Asia, while the linkages between all the other markets are much weaker. The findings are approved by multivariate cointegration analysis for the U.K. and to some lesser extent for the U.S. as well. One of the two identified cointegration equations consists of Asia-Pacific markets only. So, the benefits from diversification among the Asia-Pacific real estate markets seem to be limited.

These findings challenge the implications given by low correlation among Asian securitized real estate markets. Furthermore, investors from Asia benefit from broadening their investment horizon and from investing in real estate companies in Australia, the U.K. and the U.S. while long-term benefits from diversification across Asian markets are limited. From a perspective of investors from Australia, the U.K. or U.S., Asian markets exhibit long-term diversification opportunities whereas the real estate market of Hong Kong seems to be the most interesting one due to its long-term relationships with the other Asian markets and its geographical and economic vicinity to the fast growing Chinese market.

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