THE IMPACT OF THE GLOBAL FINANCIAL CRISIS ON ASIA-PACIFIC REAL ESTATE MARKETS: EVIDENCE FROM KOREA, JAPAN, AUSTRALIA AND U.S. REITs

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ABSTRACT

This paper analyzes the impact of the U.S. real estate market collapse on the Asia-Pacific real estate markets, by examining the Korea, Japan, Australia, and U.S. REITs indexes during the sample period of January 2004 – June 2009 with two sub-samples of before-crisis and after-crisis. The findings indicate that linkages between the U.S. and Australia REIT sectors was strong during January 2004 – June 2009. In the case of linkages between the U.S. and Korean REIT sectors, co-movements have become significant only after the breakout of global financial crisis. The Japanese REIT sector shows a weak relationship with the U.S. REIT sector. In addition, this paper shows a weak co-integration among Asia-Pacific REIT sectors. A-REITs, K-CR REITs, J-REITs show different magnitudes of contagion effects. This finding can be explained by characteristics of REITs, structure of financing, and country's economic situation.

Keywords: Global financial crisis, A-REITs, K-CR REITs, J-REITs, cointegration, error correction model

INTRODUCTION

The collapse of the US subprime mortgage market has led to the global financial crisis. The mortgage excess lending and aggressiveness in the banking industry is the primary cause of the U.S. housing bubble and subsequent crash. The increase in default on subprime mortgages has caused a crisis in U.S. financial markets, which spread into the global financial markets (Zandi, 2009; Talbott, 2009).

There has long been a decoupling argument which says that the U.S. markets no longer affects other global markets, especially emerging markets such as China, Brazil, India, and Russia. However, the recent global economic situation shows that the economic crisis that began in the U.S. has spread to other global markets.

Many empirical papers have provided evidence that the U.S. stock markets are closely linked with world markets (Eun and Shim 1989, Campbell and Hamao 1992, Hardouvelis et al. 2006). Likewise, Arshanapalli and Doukas (2006) connected international stock markets pre- and post-October 1987 financial crisis.

Even though there are many studies which examine the linkages between the global equity markets, only a few studies have focused on co-movement of real estate markets. Garvey et al. (2001) reported a limited co-integration between Australia, Japan, Hong Kong, and Singapore property markets. Zhu and Liow (2005) provide evidence of strong long-term and short-term relationships between China and Hong Kong property stock markets during the 1993-2003 period.

The aim of this study is to examine how the collapse in the U.S. real estate market affects Asia-Pacific real estate markets. Since a global real estate market allows diversification, investors can reduce risk by diversifying into different countries. Thus, it is interesting to examine contagion effects among the real estate markets across the world. That is, the question is how the relationship between the U.S. and the rest of countries, particularly in Asian-Pacific real estate markets, changes during the global financial crisis.

To investigate co-movements between real estate markets, this paper uses one REIT stock and three REIT indexes which could represent the performance of real estate markets - Macquarie Central CR REIT (hereafter 'Macquarie'), Dow Jones Composite All REIT Index (hereafter 'DJ-REIT'), Tokyo Stock Exchange REIT Index (hereafter 'J-REIT'), Dow Jones Australia LPT Index (hereafter 'DJ-LPT'). Also, to examine the impact of the global financial crisis on property, this paper divides the sample period into two subsamples – before and after the financial crisis.

The remainder of the paper is organized as follows. Section II offers a review of previous studies on relationships across global real estate markets. Section III briefly describes the data and methodology. Section IV presents the empirical results. Section V summarizes the paper.

LITERATURE

Even though there are a number of studies which examine the linkage between real estate markets and capital markets in a country, few studies analyze international real estate market integration. Because the real estate markets are thought to be more likely to be affected by domestic factors rather than international factors, it seems that the researchers show little interest on international real estate markets linkages.

Eichholtz et al. (1998) shows that rate of returns for real estate stocks are driven by continental factors in North America. However, no continental factor is found for the Asia-Pacific region. Garvey et al. (2001) details linkages among real estate securities for Australia, Japan, Hong Kong, and Singapore for the sample period of January 1975 to March 2001. Their study uses weekly data to avoid non-synchronous trading problem of daily data. Their co-integration analysis shows that there is little evidence of co-integration among the four markets, implying that there is no long-term relationship. This evidence suggests that there exist diversification opportunities for global real estate investment.

Zhu and Liow (2005) find that, using the Shanghai SE Real Estate Index and Hang Seng Property Index as benchmarks, there is a co-integration relationship between the China and Hong Kong real estate markets for the sample period of 1993 to 2003. They also provide evidence that, while there is no co-integration between the two markets before the 1997 Asian financial crisis, there exists co-integration after financial crisis. Michayluk et al (2006) find a significant interaction, on a daily basis, between U.S. and U.K. securitized real estate markets. They use synchronously priced indexes instead of close-to-close return data. Liow and Webb (2007) report nonlinear chaotic behavior in real estate market returns. They argue that, to understand co-integration of real estate markets, it is important to consider non-linear chaotic behavior in the real estate returns.

During the sample period of 1988-2008, Liow (2008) examines the international real estate market linkages using several types of indexes for U.S., U.K., Australia, Hong Kong and Singapore. There is no co-integration relationship among real estate markets of the 5 countries. However, it is found that in the case of developed real estate markets such as U.S., U.K. and Australia, there is a co-integration relationship. Bardhan et al. (2008) examined the impact of country's globalization on the real estate firms using 250 real estate companies from a set of 16 countries, including U.S., Germany, Hong Kong, Australia, Japan. They find that, for the sample period of 1995-2002, the globalization effect is significantly and negatively related to firm returns.

METHODOLOGY

Data

This paper analyzes the relationship between the U.S. real estate market and Asia-Pacific real estate markets.[1] This paper uses U.S. and two Asia-Pacific real estate market indexes - Dow Jones Composite All REIT Index (DJ-REIT), Tokyo Stock Exchange REIT Index (J-REIT), Dow Jones Australia LPT Index (DJ-LPT). For the Korean real estate market, Macquarie Central CR REIT (Macquarie) is selected. [2]

The Dow Jones Composite All REIT Index contains all the publicly traded U.S. REITs, including equity, mortgage and hybrid REITs. The Dow Jones Australia LPT Index tracks the performance of Listed Property Trusts traded on the Australian Stock Exchange.[3] The

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[1] Whiting (2007) describes characteristics of REITs in Asia-Pacific regions.
[2] Because there is no REIT index in Korea, this paper uses a single REIT – Macquarie which is currently traded on Korea Exchange.
[3] Dow Jones Australia LPT Index represents about 90% of the market capitalization of real estate investment trusts traded on ASX.

Tokyo Stock Exchange REIT Index is a capitalization weighted index based on all REITs listed on the Tokyo Stock Exchange.[4]

Australia has the second largest REIT market in the world. Australian real estate investment trusts have been established for 40 years. A-REITs, known previously as Listed Property Trusts (LPTs), account for about 12% of the world's listed real estate assets and invest in Australia, New Zealand, Europe, and North America.[5]

Japanese REITs was introduced in November 2000 and, since then, the J-REIT market has grown dramatically in terms of market capitalization and the number of REITs. 40 J-REITs are listed on Tokyo Stock Exchange as of September 2009.[6]

Macquarie Central CR REIT is the CR-REIT listed on the Korea Exchange by Macquarie Real Estate Korea Limited, a Korean subsidiary of Macquarie Real Investments (www.macquarie.co.kr/property). In 2001, Korean CR-REITs (hereafter, 'K-CR REITs') were introduced to help cash trapped firms sell their property as a way of corporate restructuring. K-CR REITs have a limited operating period and should invest at least 70% of their assets in companies undergoing restructuring due to insolvency or companies that intended to use the proceeds to pay off debt (Kim, 2008).

Dow Jones Composite All REIT Index and Dow Jones Australia LPT Index are obtained from Dow Jones Indexes (www.djindexes.com). Tokyo Stock Exchange REIT Index consists of all REITs traded on Tokyo Stock Exchange. Tokyo Stock Exchange REIT Index is collected from the the Tokyo Stock Exchange (www.tse.or.jp). Macquarie Central CR REIT stock price is obtained from the Korea Exchange (www.krx.co.kr).

Because Macquarie Central CR-REIT was listed in January 2004, the sample period from January 7, 2004 to June 12, 2009 is used. The sample has 1,417 observations.

To examine daily returns of indexes, the closing prices are transformed via a natural log as follows: for example, DJ-REIT index, LDJ-REIT = log(DJ-REIT). Macquarie, J-REIT, and DJ-LPT are also transformed in the same manner. To consider the trading hours difference between the Asia-Pacific real estate markets and U.S. real estate market, this paper matches trading dates{t} in the Asia-Pacific markets to trading dates {t-1} in the U.S. market. Thus, the DJ REIT index is transformed as log(DJ-REIT{1}).

The full sample is divided into two sub-periods to examine the impact of the global financial crisis on real estate markets. Before-crisis subsample spans from January 7, 2004 to April 2. After-crisis subsample period is from April 3, 2007 to June 12, 2009.

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[4] The Tokyo Stock Exchange REIT Index has been published from April 1, 2003.
[5] ASX website July 16, 2009(www.asx.com.au/products/pdf/a_reits)
[6] AFX News Limited March 5, 2008(www.forbes.com/feeds/afx/2008/03/05/afx4732967.html)

Figure 1 displays the DJ-REIT index and Macquarie stock prices over the sample period from January 7, 2004 to June 12, 2009. Figure 2 exhibits the DJ-REIT index and J-REIT index over the sample period. Figure 3 presents the DJ-REIT index and DJ-LPT index over the sample period. DJ-REIT and DJ-LPT show a close relationship over the sample period.

Figure 4 shows the DJ-REIT index and Macquarie stock prices over the sample period. Figure 5 displays the Macquarie stock prices and J-REIT index over the sample period. Figure 6 shows the Macquarie stock prices and DJ-LPT index over the sample period. In Figure 2, Figure 3, and Figure 4, the DJ-REIT index, J-REIT index and DJ-LPT index show a similar trend.

Figure 1: DJ-REIT index & Macquarie stock price, 2004.1.7 - 2009.6.12

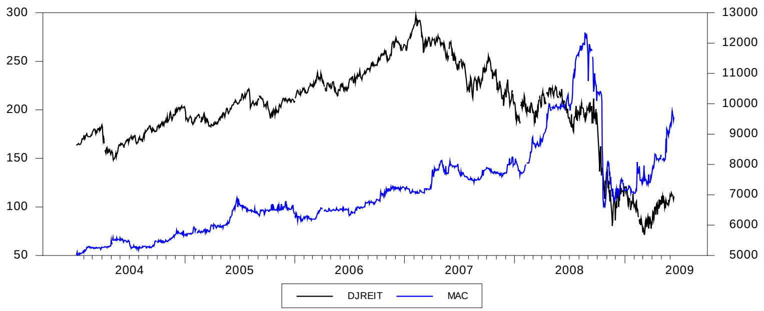


Figure 2: DJ-REIT index & J-REIT Index, 2004.1.7 - 2009.6.12

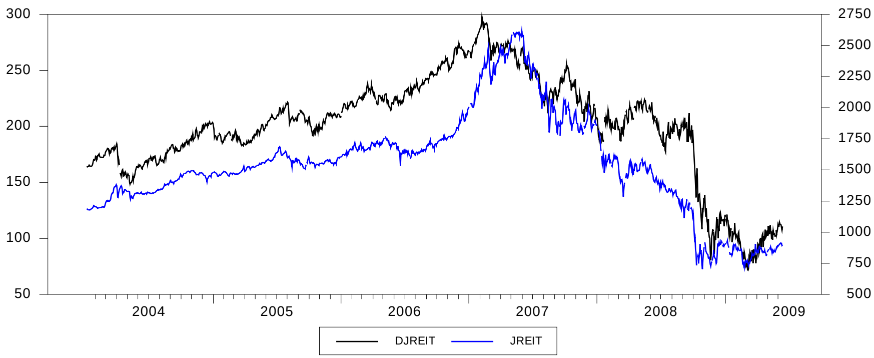


Figure 3: DJ-REIT Index & DJ-LPT Index, 2004.1.7 - 2009.6.12

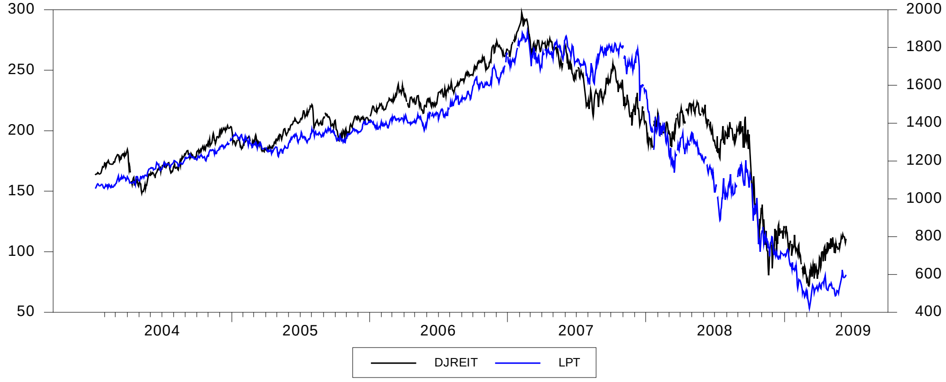


Figure 4: J-REIT index & DJ-LPT index, 2004.1.7 - 2009.6.12

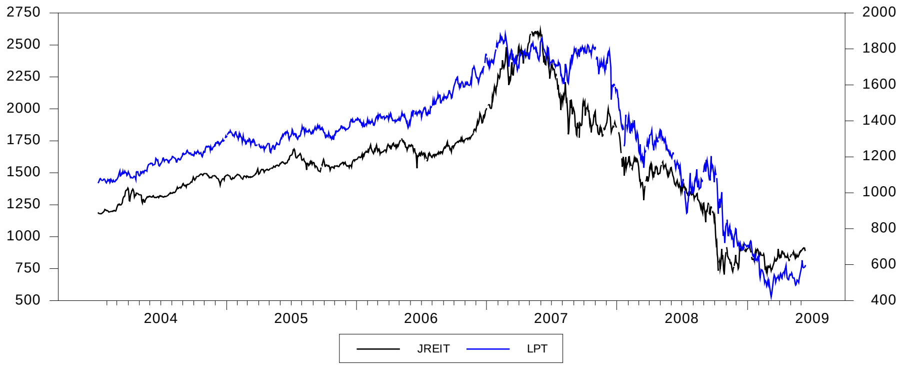


Figure 5: Macquarie stock price & J-REIT index, 2004.1.7 - 2009.6.12

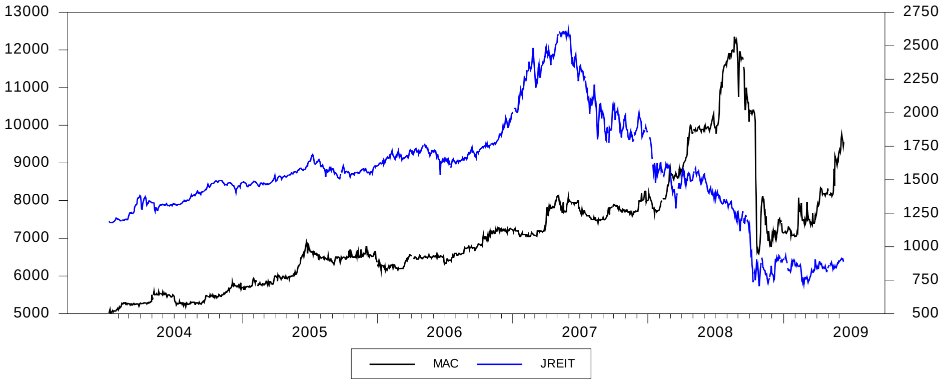
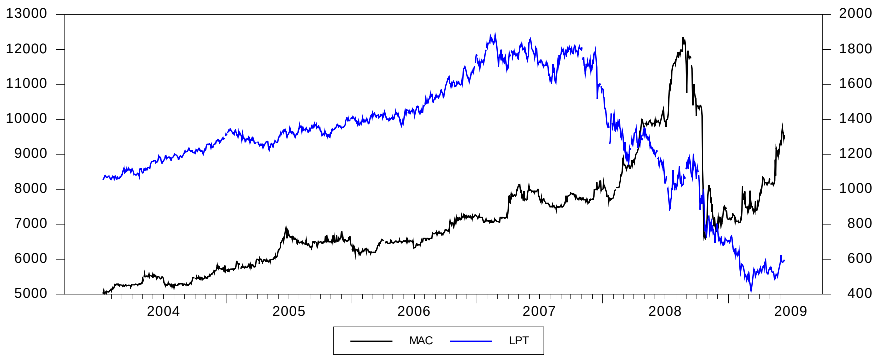


Figure 6: Macquarie stock price & DJ-LPT index, 2004.1.7 - 2009.6.12



Methodology

Unit root test

Even though two variables seem to move together, each series may be non-stationary. It is known that, if the variables are non-stationary, there may be a spurious relationship between the two variables. If there is a spurious regression, the results are of no economic significance.

To test whether time series are stationary or not, two methodologies – the Augmented Dickey Fuller (ADF) procedure and Phillips-Perron (PP) test – are mainly used.

$$\Delta X_t = \alpha_0 + \gamma X_{t-1} + \sum_{i=2}^{p} \beta_i \Delta X_{t-i+1} + \epsilon_t \quad (1)$$

where X is a time series sequence, ϵ_t is a white noise process.

Information criteria have been proposed for allowing the data to determine the length of a distributed lag. Two most commonly used are the Akaike Information Criteria (AIC) and the Schwarz Criterion (SIC). The null hypothesis of a unit root is rejected in favor of the stationary alternative in each case if the test statistics are more negative than the critical values.

Phillips and Perron have developed a more comprehensive theory of unit root non-stationarity. The tests are similar to ADF tests, but they incorporate an automatic correction to the DF procedure to allow for autocorrelated residuals. The tests often give the same conclusions, and suffer from most of the same limitations as the ADF tests. The results of these tests can be compared with the ADF/PP procedure to see if the same conclusion is obtained.

Co-integration analysis & error correction model

It is possible for two or more non-stationary data generating processes to share a long-term interdependent relationship. Thus, the linear combination of two or more non-stationary series would be stationary. Such series are said to be co-integrated. If the two series are co-integrated, the deviation from long-term equilibrium is corrected over the period through short-term adjustments. [7]

For co-integration analysis, there are two general methodologies - Engle and Granger (1987) and Johansen and Juselius (1988, 1990). It is pointed out that the Granger-Engle methodology has drawbacks such as arbitrary normalization of the variables and the difficulty in estimating the appropriate number of co-integrating vectors with such a system (Brooks, 2000).

Johansen methodology uses the ECM (error correction model) derived from the VAR model. The test for the number of co-integration vectors is performed to determine the rank of the coefficient matrix by estimating the number of eigenvalues that are significantly different from zero.

In the Johansen methodology, two test statistics – trace and maximum eigenvalue - are used as follows:

[7] This paper uses RATS 7.2 and CATS 2.0 released by Estima for statistical analysis.

$$\lambda_{max}(r, r+1) = -T \times \ln(1-\lambda_{r+1}) \quad (2)$$

$$\lambda_{trace}(r) = -T \times \sum_{i=r+1}^{n} \ln(1-\lambda_i) \quad (3)$$

where λ_i is eigenvalues derived from the π matrix, r is the rank of the matrix.

λ_{max} conduct separate tests on each eigenvalue in which the null hypothesis is that number of co-integrating vectors is r against an alternative r+1. λ_{trace} is a joint test when the null hypothesis is that the number of co-integrating vectors is less than or equal to r against an alternative that is more than r.

If two non-stationary variables are co-integrated, the error correction model is appropriate while VAR could be misspecified. However, if variables are not found to be co-integrated, tests for causality should be implemented using the following VAR model.

The generalized n-variable error correction model can be expressed in the following form.

$$\Delta X_t = \pi_0 + \pi X_{t-1} + \pi_1 \Delta X_{t-1} + \pi_2 \Delta X_{t-2} + \cdots + \pi_p \Delta X_{t-p} + \epsilon_t \quad (4)$$

where π_0 = an (n x 1) vector of intercept terms with elements π_{i0}
π_i = (n x n) coefficients matrices with elements $\pi_{jk}(i)$
π = a matrix with elements π_{jk} such that one or more of the $\pi_{jk} \neq 0$
ϵ_t = an (n x 1) vector with elements ϵ_t

EMPIRICAL RESULTS

Unit root tests

The unit root tests for the 4 REITs are performed for their stationary on the level and first difference, respectively. Table 1 reports the results of unit root test.

The column 2 of Table 1 shows that, for all variables on the level, the null hypothesis of non-stationarity cannot be rejected. In column 3, however, the null hypotheses can be rejected since the ADF statistics for the first difference of all variables are larger than the critical value. In column 3 of Table 4, the Phillips-Perron (PP) test provides the same results.

The results show that all variables – DJ-REIT, Macquarie, J-REIT, and DJ-LPT - are not stationary in level, but stationary after first difference.[8]

[8] Even though the results of unit root test for lag= 1, 2, 3, 4 are not reported in the paper, the unit root tests for lag = 1, 2, 3, 4 show all variables in the sample are non-stationary at the level but stationary at the first

Table 1: Unit root test

	ADF		PP	
	Level	First Difference	Level	First Difference
Macquarie	-0.8861	-12.5935***	-1.2883	-34.3485***
DJ-REIT	-0.7612	-15.3772***	-1.3916	-43.0060***
J-REIT	-0.7584	-14.5180***	-0.6954	-31.9678***
DJ-LPT	0.4866	-17.2574***	0.0637	-34.7863***

Note: lags=4. Critical value: DF test: 1%=-3.439, 5%=-2.864, 10%=2.568, PP test: 1%=-3.438, 5%=-2.864, 10% = -2.568, ***, **,* indicates significance at 1%, 5%, 10% level

Co-integration analysis

To perform the Johansen co-integration analysis, the appropriate lag length is selected using the Akaike Information Criteria (AIC) test. Second, the null hypothesis for the trace test is that the number of co-integrating vectors is less than or equal to r, with the alternative of larger than r. The null hypothesis for the maximum eigenvalue test is the number of co-integrating vectors is r, with the alternative of r+1.

This paper uses a restricted trend co-integration model which specifies a model with linear trends in the variables. As a robustness check on the restricted trend model, the other models – unrestricted model, restricted constant model, a model with no deterministic components – are tested. Though not reported, the results are the same as the restricted trend model.

Table 2 provides the results of bivariate co-integration tests for DJ-REIT, Macquarie, J-REIT, and DJ-LPT for the entire sample period. The results show that there is at least one co-integration vector between DJ-REIT and J-REIT, DJ-REIT and DJ-LPT, J-REIT and DJ-LPT, indicating a long-run relationship among the U.S, Japan, and Australia REIT sectors. On the other hand, there is no evidence of a co-integration between DJ-REIT and Macquarie, Macquarie and J-REIT, Macquarie and DJ-LPT. This evidence shows that, for the full sample period, there is no long-term equilibrium between U.S. and Korea, between Japan and Korea, and between Australia and Korea REIT sectors. These results are consistent with Liow and Sim (2006) which report low correlations among Asian real estate stock returns compared to common stocks.

difference. Critical value: at the level of 5% λmax =25.731, $\lambda trace$ =12.448, The critical value are taken from Osterwald-Lenum(1992)

Table 2: Bivariate co-integration tests for DJ-REIT, Macquarie, J-REIT, and DJ-LPT for full sample period

Variables		λmax	λtrace
DJ-REIT-Macquarie	r = 0	14.393	14.403
	r < 1	4.167	4.168
DJ-REIT-J-REIT	r = 0	32.950***	32.973***
	r < 1	4.226	4.227
DJ-REIT-DJ-LPT	r = 0	49.758***	49.791***
	r < 1	6.232	6.234
Macquarie-J-REIT	r = 0	18.028	18.041
	r < 1	2.658	2.659
Macquarie-DJ-LPT	r = 0	11.826	11.834
	r < 1	2.136	2.137
J-REIT-DJ-LPT	r = 0	25.531**	25.549**
	r < 1	3.200	3.201

Note: lag = 1. The trace tests and maximum eigenvalue are obtained from the Johansen Full Information Likelihood co-integration regressions. The critical value are taken from simulation in RATs, ***, **, * indicates significance at 1%, %, 10% level

This paper examines the effect of the recent global financial crisis on Asia-Pacific real estate markets. To test the impact of global financial crisis on Asia-Pacific real estate markets, this paper divides the full sample into two subperiods – before and after crisis.

Table 3 reports the results of co-integration tests for DJ-REIT, Macquarie, J-REIT and DJ-LPT before and after the financial crisis. When the analysis is conducted on the sub-samples, in the case of DJ-REIT and Macquarie, before the crisis, there is no co-integrating factor between the two indexes, whereas, after the crisis, there is a co-integration relationship. These results imply that, since the U.S. subprime mortgage crisis, the Korean real estate market have been influenced by the U.S. real estate market. After the global financial crisis, the demand for real estate has reduced, where cash trapped companies, including foreign investors, tried to sell their real estates.[9] Additionally, K-CR REITs have experienced difficulty in raising capital.

In particular, the evidence in Table 3 shows that the extent of co-movements between DJ-REIT and J-REIT is not statistically significant, though it has been stronger after crisis. As exposure of the banks to the real estate markets increased, in 2007, the Japanese government ordered banks to reduce lending before the credit crunch resulted from the global financial crisis.[10] Thus, Japanese real estate markets have been much less hit, though REIT sectors suffered some losses.

[9] Referred from article (Korean version) 'REITs prices drop on sell-off,' www.moneytoday.co.kr, 2008.11.2.
[10] Referred from article 'Is Japan real estate poised for a gold rush?' www.financeasia.com, 2008.11.18; Article, U.S. Subprime Woes Have Limited Impact on Japanese REITs – S&P May 26, 2009 (www.seekapha.com/article/13598-japan-s-j-reit-market-to-get-a-10-5-billion-bailout).

In case of DJ-REIT-DJ-LPT, before and after the global financial crisis, a co-integration is observed. This evidence suggests that the relationship between the U.S. and Australian REIT sectors has long been strong. This evidence is consistent with Liow (2008) who found a co-integration relationship among the developed REIT markets such U.S., U.K. and Australia.

A-REITs experienced financing problems due to the global credit crunch resulting from the collapse of global investment banks. According to ASX Investor Update (2009), A-REIT stock prices have a tendency to move in tandem with U.S. large banks stock prices.[11] In addition, as Appendix I and II show, the U.S. and Australian stock markets exhibit strong linkages during the sample period.[12]

In addition, the co-integration relationship is not found before and after the global financial crisis among Asia-Pacific REIT markets except for Macquarie and J-REIT. These results are consistent with the evidence presented by Garvey, Santry, and Stevenson (2001), Liow (2008), in which little co-integration relationship among the developing REIT markets is reported.

Table 3: Bivariate co-integration tests for DJREIT, Macquarie, J-REIT, and DJ-LPT before and after financial crisis (2004.1.7-2007.4.2 and 2007.4.3-2009.6.12)

Variables		2004.1.7-2007.4.2		2007.4.3-2009.6.12	
		λmax	*λtrace*	*λmax*	*λtrace*
DJREIT-Macquarie	r = 0	18.137	18.158	41.251***	41.323***
	r < 1	8.739	8.743	1.919	1.920
DJREIT-J-REIT	r = 0	15.817	15.836	22.471	22.510
	r < 1	2.234	2.345	3.653	3.655
DJREIT-DJ-LPT	r=0	23.378*	23.40*	32.804***	32.858***
	r < 1	9.071	9.075	6.253	6.256
Macquarie-J-REIT	r = 0	12.890	12.905	32.317***	32.373***
	r < 1	1.972	1.973	2.526	2.527
Macquarie-DJ-LPT	r = 0	18.065	18.086	16.003	16.030
	r < 1	8.416	8.420	1.873	1.874
J-REIT-DJ-LPT	r = 0	15.064	15.082	14.878	14.904
	r < 1	2.502	2.503	4.703	4.706

Note: lag = 1. The trace tests and maximum eigenvalue are obtained from the Johansen Full Information Likelihood co-integration regressions. The critical value are taken from simulation in RATs, ***, **, * indicates significance at 1%, 5%, 10% level

The results of the multivariate co-integration analysis are provided in Table 4. The evidence in Table 4-Panel A shows that, for the full sample, there are more than one co-

[11] Referred from article 'The outlook for listed property,' September 2009 ASX Investor Update, September 16, 2009 (www.asx.com.au).
[12] In Appendix I, II, this study presents the results of co-integration analysis for equity prices of 4 countries – U.S. (Dow Jones Industrial Average), Korea (KOSPI), Japan (Nikkei225), and Australia (S&P/ASX200).

integration relation, suggesting that there is a long-term equilibrium between U.S. and the Asia-Pacific real estate markets.

In Table 4-Panel B, the evidence shows that, before the financial crisis, a co-integration relationship does not exist, while, after the financial crisis, a co-integration relationship exists. Meanwhile, Liow and Sim (2006) find that the U.S. real estate index has relatively low correlation with the Asian real estate indexes over the period of 1990-2003.

The results in Table 4 suggest that, after the crisis, Asia-Pacific real estate markets tend to move closely with the U.S. real estate market. The downturn in the equity market, credit crunch, and economic slump across the world might affect the Asia-Pacific REIT sectors.

Table 4: Multivariate co-integration tests for DJREIT, Macquarie, J-REIT, and DJ-LPT, for full sample period and before and after financial crisis (2004.1.7-2007.4.2 and 2007.4.3-2009.6.12)

Panel A: Full sample		
	λmax	*λtrace*
r = 0	122.591***	122.813***
r < 1	57.057***	57.131***
r < 2	20.735	20.751
r < 3	3.253	3.254

Panel B: subsample				
	2004.1.7-2007.4.2		2007.4.3-2009.6.12	
	λmax	*λtrace*	*λmax*	*λtrace*
r = 0	29.018	29.106	100.952***	101.413***
r < 1	16.964	17.001	51.143***	51.308***
r < 2	8.191	8.202	16.948	16.982
r < 3	1.141	1.142	3.970	3.972

Error correction model analysis

Given the co-integration relationship in Table 3, several bivariate error correction models are estimated. Table 5 provides the empirical results of the bivariate error correction model for DJ-REIT-J-REIT, DJ-REIT-DJ-LPT, and J-REIT-DJ-LPT.

The empirical results in Table 5 indicate that the error correction term is found to be significant at the level of at least 5% except for the case in which J-REIT is a dependent variable in Panel A. This evidence suggests that there is a long-term price adjustment process between the U.S. and Korean, Australian, Japanese real estate markets. Also, the coefficients of the lagged DJ-REIT are significant, indicating the U.S. REIT sector influences the Japan and Australia REIT sectors. The evidence shown in Table 5 indicates a strong short-term lead/lag relationship between the U.S. and Japan, Australian real estate markets. This evidence shown in Table 5 implies that there is a limited diversification effects among U.S. and Asia-Pacific real estate markets.

Table 5: Error correction model for DJREIT, Macquarie, J-REIT, and DJ-LPT for full sample period

Panel A: DJREIT-J-REIT		
Dependent variables	DJ-REIT	J-REIT
DJ-REIT{1}	-0.2119***	0.2067***
DJ-REIT{2}	-0.0541*	0.0998***
J-REIT{1}	0.0085	0.0494
J-REIT{2}	-0.0037	0.0199
EC{1}	-0.0021***	0.0008
Panel B: DJ-REIT-DJ-LPT		
Dependent variables	DJ-REIT	DJ-LPT
DJ-REIT{1}	-0.2337***	0.2104**
DJ-REIT{2}	-0.0820***	0.0895***
DJ-LPT{1}	0.0049	0.0011
DJ-LPT{2}	-0.1887***	0.0263
EC{1}	-0.0014**	0.0021***
Panel C: J-REIT-DJ-LPT		
Dependent variables	J-REIT	DJ-LPT
J-REIT{1}	0.1143***	0.0070
J-REIT{2}	-0.0358	0.0789**
DJ-LPT{1}	0.0267	0.1247***
DJ-LPT{2}	0.1152***	-0.0739**
EC{1}	0.0011**	-0.0012**

Table 6 shows the empirical results of the bivariate error correction model for the sample of 'after crisis'.[13] The significance of the error correction terms depends on the dependent variables. For example, in Table 6-Panel A, where Macquarie is a dependent variable, the error correction term is found to be significant at the level of 5%. In Table 6-Panel B and Table 6-Panel C, the error correction terms are not significant when dependent variables are DJ-REIT and J-REIT respectively.

[13] Because no bivariate co-integration between DJ-REIT and J-REIT is found, this paper does not perform error correction analysis for DJ-REIT and J-REIT.

In addition, Table 6 indicates that there is a short-term lead/lag relationship between DJ-REIT and Macquarie, DJ-LPT. It is shown that DJ-REIT have influenced Macquarie and DJ-LPT after the financial crisis, suggesting an increasing influence on both Korean and Australian real estate markets after the global financial crisis by U.S. real estate markets.

Table 6: Error correction model for DJ-REIT, Macquarie, J-REIT, and DJ-LPT, after financial crisis (2007.4.3-2009.6.12)

Panel A: DJ-REIT-Macquarie		
Dependent variables	DJ-REIT	Macquarie
DJ-REIT{1}	-0.2495***	0.0182
DJ-REIT{2}	-0.1104***	0.0550***
Macquarie{1}	0.3430***	0.0587
Macquarie{2}	0.0348	0.2813***
EC{1}	0.0012	0.0017**
Panel B: DJ-REIT-DJ-LPT		
Dep. variables	DJ-REIT	DJ-LPT
DJ-REIT{1}	-0.2684***	0.2077***
DJ-REIT{2}	-0.1016**	0.0935**
LPT{1}	0.0167	0.0090
LPT{2}	-0.2141***	0.0290
EC{1}	-0.0022	0.0038***
Panel C: Macquarie-J-REIT		
Dep. variables	Macquarie	J-REIT
Macquarie{1}	0.0732	-0.0947
Macquarie{2}	0.2776***	0.0022
J-REIT{1}	0.0503	0.0855*
J-REIT{2}	-0.0134	-0.0188
EC{1}	0.0015*	0.0003

The results of multivariate error correction model after the financial crisis appears in Table 7. The results show that the error correction terms are significant for the equation in which Macquarie and DL-LPT are dependent variables. The analysis of a short-term lead/lag relationship shows that DJ-REIT has explanatory power on J-REIT and DJ-LPT. In Table 7, it is confirmed that A-REITs are closely related to U.S. REITs. Interestingly, the evidence shows that Macquarie and DJ-LPT have influenced DJ-REITs after the global financial crisis.

Table 7: Multivariate error correction model for DJREIT, Macquarie, J-REIT, and LPT, after financial crisis (2007.4.3-2009.6.12)

Dep. variables	DJ-REIT	Macquarie	J-REIT	DJ-LPT
DJREIT{1}	-0.2656***	-0.0132	0.1851***	0.1888***
DJREIT{2}	-0.0964	0.0078	0.0971***	0.0835**
Macquarie{1}	0.2932***	0.0676	-0.0714	-0.0758
Macquarie{2}	0.1807*	0.3084***	-0.0981	0.0973
J-REIT{1}	-0.0861	0.0563	-0.0077	-0.0553
J-REIT{2}	0.0385	-0.0204	-0.0212	0.1537***
DJ-LPT{1}	0.0771	-0.0282	0.0003	0.1201**
DJ-LPT{2}	-0.2430***	-0.0081	0.1628***	-0.0525
EC{1}	-0.0035	0.0039***	0.0014	0.0025*

CONCLUSIONS

The financial crisis caused by the mortgage meltdown in the U.S. has spread across the world. The Asia-Pacific countries as well as the U.S. suffered substantial losses in both the equity and real estate markets. The current global financial crisis raised questions of how the U.S. financial crisis affects the rest of the world economy.

This study investigates how the U.S. real estate market affects Asia-Pacific real estate markets before and after the recent financial crisis, using REIT indexes. This paper intends to contribute to the literature in global real estate asset management after the global financial crisis.

The findings in this paper indicate that the Australian real estate market is closely related to the U.S. real estate market during the sample period. After the financial crisis, the Korean real estate market is affected by the U.S. real estate market. However, the magnitude of impacts of financial crisis on the Japanese REIT sector is not significant. Meanwhile, it is found that there is a weak co-integration among Asia-Pacific real estate markets. The multivariate co-integration results indicate that before the financial crisis, there is no co-integration between the U.S., Australia, Japan and Korea. But after the global financial crisis, the U.S. and Asia-Pacific real estate markets show a long-run relationship.

The empirical results found in this paper suggest that there is a limited contagion effect of the global financial crisis on real estate markets. In other words, benefits of international portfolio diversification in the real estate markets might decrease after the global financial crisis.

The results in this paper also imply as follows: First, real estate market linkages between the U.S. and Australia, Korea and Japan might be affected by the fall in equity prices, credit crunch, and downturn in real estate prices. Second, the extent of the contagion effect can depend on the characteristics of REITs, capital structure of REITs such as levels of gearing, asset portfolio quality, and country's economic situation.

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Appendix I: Bivariate co-integration tests for DJIA, KOSPI, Nikkei225, and S&P/ASX200 for full sample period

Variables		λmax	λtrace
DJIA-KOSPI	r = 0	18.440	18.452
	r < 1	1.109	1.109
DIJA-Nikkei225	r = 0	16.040	16.051
	r < 1	3.376	3.377
DIJA-S&P/ASX200	r = 0	28.155**	28.172**
	r < 1	3.304	3.304

Note: DJIA: Dow Jones Industrial Average, KOSPI: Korea Stock Price Index, lag = 1. The trace tests and maximum eigenvalue are obtained from the Johansen Full Information Likelihood co-integration regressions. The critical value are taken from simulation in RATs, ***, **, * indicates significance at 1%, 5%, 10% level

Appendix II: Bivariate co-integration tests for DJIA, KOSPI, Nikkei225, and S&P/ASX200 before and after financial crisis (2004.1.7-2007.4.2 and 2007.4.3-2009.6.12)

Variables		2004.1.7-2007.4.2		2007.4.3-2009.6.12	
		λmax	*λtrace*	*λmax*	*λtrace*
DIJA-KOSPI	r = 0	19.701	19.724	23.122*	23.161*
	r < 1	4.303	4.305	4.957	4.960
DIJA-Nikkei225	r = 0	13.306	13.321	16.467	16.496
	r < 1	2.198	2.199	2.299	2.300
DJIA-S&P/ASX200	r=0	27.410*	27.439*	28.636**	28.682**
	r < 1	12.257	12.261	4.575	4.578

Note: DJIA: Dow Jones Industrial Average, KOSPI: Korea Stock Price Index, lag = 1. The trace tests and maximum eigenvalue are obtained from the Johansen Full Information Likelihood co-integration regressions. The critical value are taken from simulation in RATs, ***, **, * indicates significance at 1%, 5%, 10% level

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