The U.S. QE and Volatility Spillover Effects among the U.S. and Asia-Pacific Real Estate Markets: Evidence from REIT ETFs

미국의 양적 완화정책과 미국과 아시아-태평양 부동산시장 간 변동성 전이 효과 : 리츠 상장지수펀드

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국문초록

1. 내용

(1) 연구목적

본 연구는 미국의 양적완화정책이 실시된 2010~2015년 동안 리츠 ETF를 이용하여 미국과 아시아-태평양 국가 간 변동성 전이 효과를 분석하고자 한다.

(2) 연구방법

본 연구는 bivariate GJR-BEKK-GARCH 모형을 이용하여 각 리츠 ETF 간 변동성 전이 효과가 존재하는지에 대해 분석하였다.

(3) 연구결과

실증분석결과에 의하면 미국 부동산시장과 아시아-태평양 국가의 부동산시장 간에 강한 변동성 전이 효과가 존재하는 것으로 나타났다. 호주의 경우도 아시아-태평양국가들과 변동성 전이 효과를 가지고 있는 것으로 분석되었다.

2. 결 과

본 연구결과에 의하면 미국과 아시아-태평양 국가 부동산시장 간에 변동성 전이 효과가 존재하는 것으로 나타났다.

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▷ 접수일(2016년 8월 5일), 수정일(1차 : 2016년 8월 20일, 2차 : 2016년 9월 1일), 게재확정일(2016년 12월 16일)

따라서 통상 지역성이 강한 것으로 알려진 부동산시장도 글로벌 부동산시장의 움직임에 민감하게 반응하는 것으로 나타났다. 이러한 본 연구의 분석결과가 최근 저금리로 인해 글로벌 부동산투자에 대한 관심이 높아지고 있는 때에 투자자들의 포트폴리오 전략수립 시 도움이 될 것으로 기대한다.

3. 핵심어

• 리츠 상장지수펀드, 양적완화정책, 동조화, 부동산시장, 변동성 전이

ABSTRACTS

This paper addresses linkages among the U.S., Australia, Japan, and China real estate markets in the case of REIT(real estate investment trusts) ETF(exchange traded funds)s during 2010-2015 in which the U.S. Federal Reserve implemented the monetary stimulus, so-called quantitative easing (QE). The purpose of this study assesses the impact of the U.S. QE on Australia, Japan, and China's real estate markets.

The results show that, despite locality of real estate markets, U.S. REIT ETF has volatility spillover effects on Asia-Pacific REIT ETFs. During the U.S. QE period in which led to low interest rate across the world, the U.S. and Australia, Japan, China real estate markets are closely related in terms of volatility spillover.

KEY WORDS : REIT ETFs, quantitative easing, co-movements, real estate markets, volatility spillover

Ⅰ. Introduction

In a response to the financial crisis started from the collapse of subprime mortgage markets, in 2007, the U.S. Federal Reserve started to increase money supply or liquidity. Since November 25, 2008, the U.S. Federal Reserve implemented three stages of expansionary monetary policies, so-called quantitative easing (QE). The U.S. Federal Reserve continued its expansionary monetary policy until October 29, 2014 and lifted its benchmark interest rates on December 17, 2015.

Thanks to the Fed's easy money policy during November 25, 2008 through December 17, 2015, with liquidity being injected into the financial markets, market interest rates were lowered, leading to cheaper cost of borrowing. (Eickmeier et al., 2014[1]; Bhattari et al., 2015[2])[3] It is generally said that the real estate markets could benefit from low interest

1) Eickmeier, S., L. Gambacorta and B. Hofmann, "Understanding Global Liquidity", *European Economic Review*, 2014, Vol.68, pp.1-18.

2) Bhattarari, S., A. Chatterjee and W. Y. Park, "Effects of U.S. Quantitative Easing on Emerging Market Economies", Federal Reserve Bank of Dallas, *Globalization and Monetary Policy Institute Working Paper*, 2015, No.255, pp.1-68.

3) The goal of QE was to cut the long-term interest rates to spur the economic activity. The QE policy started in 2008 by the U.S. Federal Reserve accelerated the capital flows into the Asia Pacific markets. (Bhattarai et al., 2015)

rates. Fratascher (2012)[4] reports large shifts in portfolio allocation involving with global capital flows.

The U.S. financial crisis had an adverse impact on the world economy, driving many countries into recession. Thus, Australia, Japan, and China also adopted easy money policy to revive their economies. Chinese government had taken a series of measures to weather the global financial crisis.[5] With high liquidity, Chinese private real estate market enjoyed upturns, seeing rising real estate prices. Japanese real estate markets also experienced rises in prices of real estate due to Bank of Japan's easy money policy.

There are many research papers which studied the co-movements of stock markets across borders, with their results being not inconclusive. (Kearney and Lucey, 2004[6]; Degryse et al., 2010[7]) Some papers provide evidence on the degree of co-integration among countries. However, there are a few papers dealing with co-movements of real estate markets.

This paper analyzes co-movement of real estate markets among the U.S. Australia, Japan, and China during the QE period. There are two conflicting arguments about the possibility of co-movement of real estate markets across the countries.

It is known that the real estate markets have unique characteristics in each country. Thus, there is an argument that, unlike stocks, the real estate market of one country goes their own way apart from other countries in terms of price movements.

Another argument holds that, due to globalization and liberalization of capital markets, which make easier capital movement across the border; therefore, real estate markets are likely to show co-movement across the countries. That is, the real estate markets are subject to global economic or capital market situation.

This paper tries to contribute to the area of co-movements of financial markets across the countries in four points apart from previous papers. First, this paper studies the co-movement of real estate market across the borders. Four countries studied in this paper are the U.S., Australia, Japan, and China.

Second, unlike the previous papers using the real estate index, this paper uses REIT ETFs (Real Estate Investment Trust Exchange Traded Funds) which are funds that track REIT index. REIT is an investment vehicle that invests in the real estate like office building, infrastructure, hotel, warehouse, and so on. ETF is a kind of index fund, which follows a specific index.

4) Fratzscher, M., "Capital Flows, Push versus Pull Factors and the Global Finance Crisis", *Journal of International Economics*, 2012, Vol.88, No.2, pp.341-356.

5) The PBoC (People's Bank of China) implemented three major policies. First, the PBoC tried to maintain an appropriate level of liquidity in the markets. Second, the PBoC has increased flexibility in the foreign exchange market by expanding the floating band further. Third, the PBoC had made an effort to improve its macro-prudential management system with differentiated reserve requirement, transparency, rule, and enhanced monitoring and reviewing the markets for financial stability. (BIS paper, 2014, No.78, pp.127-129)

6) Kearney, C. and B. Lucey, "International Equity Market Integration: Theory, Evidence, and Implications", *International Review of Financial Analysis*, 2004. Vol.13, No.5, pp.571-583.

7) Degryse, H., A. Elahi, and M. Penas, "Cross-Border Exposures and Financial Contagion", *International Review of Finance,* 2010, Vol.10, No.2, pp.209-240.

However, unlike an index fund, ETF is traded on the stock market just like stock, providing an investor a chance to buy and sell during the trading hours.[8] In Korea, KINDEX U.S. REITs ETF (listing date: 2013.8.1), TIGER MSCI U.S. REIT ETF (listing date: 2013.10.10), MiraeAsset Global REIT ETN (listing date: 2016.7.6.), and MiraeAsset U.S. REIT ETN are traded on the Korea Exchange.

Third, the U.S. quantitative easing taken by the U.S. Federal Reserve affected the global economy and capital markets. This paper might show whether the U.S. quantitative easing policy has impacts on the real estate markets of other countries, especially Australia, Japan, and China.

The remainder of this paper is as follows: The next section reviews the previous research, and in Section III, the data and methodology are explained. Section IV presents the empirical outcomes, and the conclusions are provided in Section V.

Ⅱ. Previous Literature

To the best of my knowledge, the previous studies about REIT ETFs cannot be found. However, there are some papers analyzing real estate market linkages across the borders.

Garvey, Gary and Stevenson (2001)[9] study linkages among real estate securities for Australia, Japan, Hong, and Singapore for the sample period of January 1975 to March 2001, using weekly data to avoid the non-synchronous trading problem of daily data. Their co-integration analysis shows that there is little evidence of co-integration among four markets - Australia, Japan, Hong Kong, and Singapore, implying that there is no long-term relationship. This evidence suggests that there exists the diversification opportunity for global real estate investments.

Zhu and Liow (2005)[10] present evidence of strong long-term and short-term relationships between the Shanghai SE Real Estate Index and Hang Seng Property Index during the period of 1993-2003. Their finding also shows that, while there is no co-integration between two markets before 1997 Asian financial crisis, there exists co-integration after the financial crisis.

With weekly S&P Global Property Index, Liow (2007)[11] examines the effect of Asian financial crisis on the time-varying volatility of Asia-Pacific, U.K., and U.S. real estate securities for the sample

8) Many investors looking forward to maintaining real estate allocation moved towards alternative such REITs to compliment their illiquid real estate portfolios. REITs accessed through ETFs have recently become popular among investors looking for more liquid access to real estates. www.ishares.com. iShares REIT ETFs, portfolio benefits and implementation Guide, 2011.

9) Garvey, R., R. Gary and S. Stevenson, "The Linkages Between Real Estate Securities in the Asia-Pacific", *Pacific Rim Property Research Journal*, 2001, Vol.7, No.4, pp.240-258.

10) Zhu, H. and K. H. Liow, "Relationship Between the Shanghai and Hong Kong Property Stock Market", *Pacific Rim Property Research Journal*, 2005. Vol.11, No.1, pp.24-44.

11) Liow, K. H., "The Dynamics of Return Volatility and Systematic Risk in International Real Estate Security", *Journal of Property Research*, 2007, Vol.24, No.1, pp.1-29.

period of 1992~2004. The findings show that Asian financial crisis increases Asia-Pacific real estate securities markets - Hong Kong, Singapore, and Malaysia.

In the analysis of long-term and short-term co-movements between Asia-Pacific and U.S./ U.K. during the period of January 1992-December 2008, Schindler (2009)[12] finds the long-term equilibrium relationships among Asian real estate monthly indices - Hong Kong, Japan, Singapore, Malaysia, Australia, New Zealand, and Philippines. No long-term equilibrium between U.K. and Asia-Pacific real estate markets is found. In addition, U.S. real estate markets have a weak co-integrating relationship with Asia-Pacific real estate markets.

During the sample period of 1988-2008, Liow (2010)[13] examines the international real estate market linkages using several types of indexes for U.S., U.K., Australia, Hong Kong, and Singapore. He documents that there is no co-integration relationship among real estate markets of five countries. However, it is found that in the case of developed real estate markets such as U.S., U.K., and Australia, there is co-integration relationship.

Ⅲ. Data and Methodology

This study uses daily time series of the U.S., Australia, Japan and China REIT ETF index from May 7, 2010 to December 30, 2015. The properties on the rate of returns are given in ⟨Table 1⟩. Returns, R_t, are defined by taking the first differences of the logarithm of P_t series(P_t is the price index at time t).

$$R_t = (\ln P_t - \ln P_{t-1}) \times 100 = (\ln \frac{P_t}{P_{t-1}}) \times 100$$

⟨Table 1⟩ Descriptive statistics for daily returns

This table reports descriptive statistics for the returns on the U.S., Australia, Japan and China REIT ETF index, for the period from May 7, 2010 to December 30, 2015. $Q^2(10)$ is the Ljung-Box statistics based on the first ten serial correlations of the squared returns. *** indicates significance at the 1% level.

	VNQ - Vanguard REIT ETF (U.S.)	SLF - SPDR S&P/ASX200 listed property fund (Australia)	Nextreit - REIT index fund (Japan)	SHSZ - UBS SDIC SHSZ300 finance real estate index fund (China)
observations	1232	1232	1232	1232
mean	0.040026	0.034468	0.048422	0.038506
std. dev.	1.349422	1.322406	1.245248	1.847723
skewness	-0.094280	-0.566047	0.387045	-0.040334
kurtosis	11.42708	19.35942	15.03575	7.162639
J-B	3647.300***	13804.16***	7466.863***	889.8156***
$Q^2(10)$	273.03***	361.09***	316.62***	177.29***

12) Schindler, F., "Long-Term Benfits from Investing in Asia-Pacific Real Easte", *Pacific Rim Property Research Journal*, 2009, Vol.15, No.3, pp.335-357.

13) Liow, K H., "International Direct Real Estate Market Linkages: Evidence from Time-Varying Correlation and Cointegration Tests", *Journal of Real Estate Literature*, 2010, Vol.18, No.2, pp.283-312.

〈Table 1〉 presents descriptive statistics. The kurtosis values of the four return series are much higher than three, indicating that the four time-series data are leptokurtic. According to the Jarque-Bera test, the four series are non-normal at 1% level.

The four time-series show that $Q^2(10)$s are significant, which indicates the presence of volatility clustering. That is, time-varying second moments have been detected in the four return series. Therefore, the use of GARCH-type models is justified.

Ⅳ. Empirical Results

1. Unit Root Test

〈Table 2〉 ADF Unit root test results

This table reports the ADF unit root test results for the U.S., Australia, Japan and China REIT ETF index returns. *** denotes rejection of unit root hypothesis at the 1% level.

variable	lag length	ADF statistic
VNQ return	0	-37.35433***
SLF return	2	-25.56571***
Nextreit return	0	-31.48656***
SHSZ return	0	-36.11734***

ADF test results confirm that the unit root hypothesis is rejected in each series. That is, the U.S., Australia, Japan and China REIT ETF return series are stationary.

2. Volatility Spillover Effects among REIT ETFs of Asia-Pacific Countries

In this paper, bivariate GJR-BEKK-GARCH model is employed to examine the volatility spillover effects. The bivariate GJR-BEKK-GARCH(1,1) model in this study is as follows.

Mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$

$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

Variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

where $C=\begin{pmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{pmatrix}$, $A=\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$,

$B=\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}$, $D=\begin{pmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{pmatrix}$,

$$\omega_{t-1} = \begin{pmatrix} \omega_{1,t-1} \\ \omega_{2,t-1} \end{pmatrix} = \begin{pmatrix} \max(0, \epsilon_{1,t-1}) \\ \max(0, \epsilon_{2,t-1}) \end{pmatrix}$$

1) Volatility Spillover Effects between U.S. REIT ETF and Australia REIT ETF

〈Table 3〉 shows the estimates of bivariate GJR-BEKK-GARCH(1,1) for U.S. REIT ETF and Australia REIT ETF. To see whether the bivariate GJR-BEKK-GARCH(1,1) model is correctly specified, Ljung-Box Q^2 test was used. If the bivariate GJR-BEKK-GARCH(1,1) model is correctly specified, Q^2 statistic should not be significant.

$Q^2(10)$ is the Ljung-Box statistic based on the first ten serial correlations of the squared residuals. The result from Ljung-Box Q^2 test shows that the bivariate GJR-BEKK-GARCH(1,1) model is correctly specified. The statistic for the squared standardized residuals is insignificant, suggesting that the null hypothesis(no serial correlation in squared residuals) is accepted. That is, there do not

〈Table 3〉 GJR-BEKK-GARCH(1,1) model for U.S. REIT ETF and Australia REIT ETF

This table reports the estimated results of the bivariate GJR-BEKK-GARCH(1,1) model for U.S. REIT ETF and Australia REIT ETF. ***, * denote statistical significance at the 1% and 10% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: U.S. REIT ETF, $r_{2,t}$: Australia REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.05276*	1.86550
μ_2	0.03636	1.57743
c_{11}	0.20109***	22.56366
c_{21}	0.22790***	11.36173
c_{22}	0.34454***	26.19894
a_{11}	0.23720***	38.89335
a_{12}	0.00659	0.47609
a_{21}	0.09303***	7.41199
a_{22}	0.40817***	29.91421
b_{11}	0.93187***	607.33092
b_{12}	-0.03230***	-6.85514
b_{21}	-0.01843***	-2.95679
b_{22}	0.82256***	170.00394
d_{11}	-0.26049***	-22.47938
d_{12}	-0.19701***	-7.96182
d_{21}	-0.06447***	-4.86798
d_{22}	0.38526***	19.56019
$Q^2(10)$	51.37917 (P value: 0.10724)	
lnL	-3824.1277	

appear to be any remaining ARCH effects up to order 10 in the squared standardized residuals. Therefore, this bivariate GJR-BEKK-GARCH(1,1) model is correctly estimated.

As shown in 〈Table 3〉, b_{12} and b_{21} are statistically significant at the 1% level. This means that there exist bidirectional volatility spillover effects between U.S. REIT ETF and Australia REIT ETF.

2) Volatility Spillover Effects between U.S. REIT ETF and Japan REIT ETF

〈Table 4〉 GJR-BEKK-GARCH(1,1) model for U.S. REITs and Japan REITs

This table reports the estimated results from bivariate GJR-BEKK-GARCH(1,1) model for U.S. REIT ETF and Japan REIT ETF. ***, ** denotes statistical significance at the 1% and 5% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: U.S. REIT ETF, $r_{2,t}$: Japan REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.04714*	1.89272
μ_2	0.06267***	2.87269
c_{11}	0.16714***	19.02824
c_{21}	0.08741***	4.78544
c_{22}	0.34622***	65.97974
a_{11}	0.18799***	31.51978
a_{12}	-0.03593***	-2.79144
a_{21}	0.04108***	4.52931
a_{22}	0.47023***	54.21253
b_{11}	0.94587***	804.19272
b_{12}	-0.00595*	-1.73911
b_{21}	-0.02214***	-4.52829
b_{22}	0.83802***	312.27237
d_{11}	-0.29573***	-36.72919
d_{12}	-0.09766***	-8.32972
d_{21}	-0.08813***	-6.66833
d_{22}	-0.02166	-0.69191
$Q^2(10)$	45.72274 (P value: 0.24654)	
lnL	-3748.3697	

$Q^2(10)$ statistic in 〈Table 4〉 is statistically insignificant. This means that there do not exist any remaining serial correlations in squared residuals judging from $Q^2(10)$ statistic. Therefore, the this bivariate GJR-BEKK-GARCH(1,1) model is successfully specified.

As shown in ⟨Table 4⟩, b_{12} is statistically significant at the 10% level and b_{21} statistically significant at the 1% level. This means that there exist two-way volatility spillover effects between U.S. REIT ETF and Japan REIT ETF. However, the magnitude of volatility spillover is stronger in the case of U.S. REIT ETF on Japan REIT ETF, indicating the strong influence of U.S. real estate market on Japan.

3) Volatility Spillover Effects between U.S. REIT ETF and China REIT ETF

$Q^2(10)$ statistic in ⟨Table 5⟩ shows that there does not exist any ARCH effect up to order 10 in squared residuals. Therefore, this bivariate GJR-BEKK-GARCH(1,1) model is adequately specified.

As shown in ⟨Table 5⟩, b_{12} is not statistically significant, but b_{21} is statistically significant at the 1% level, suggesting that there exists one-way volatility spillover effect from U.S. REIT ETF to China REIT ETF.

The results in ⟨Table 3⟩, ⟨Table 4⟩, and ⟨Table 5⟩ are consistent with findings of Chen (2011)[14] in which U.S. QE had significant spillover effects on Asia.

⟨Table 5⟩ GJR-BEKK-GARCH(1,1) model for U.S. REIT ETF and China REIT ETF

This table reports the estimated results of the bivariate GJR-BEKK-GARCH(1,1) model for U.S. REIT ETF and China REIT ETF. ***, **, * denotes significance at the 1%, 5% and 10% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: U.S. REIT ETF, $r_{2,t}$: China REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.04572*	1.67604
μ_2	0.03021	0.69681
c_{11}	0.18781***	9.37946
c_{21}	-0.02098	-0.65918
c_{22}	0.23648***	6.22675
a_{11}	0.24780***	15.75098
a_{12}	-0.026890	-1.02530
a_{21}	-0.01242	-1.51298
a_{22}	0.21500***	13.05401
b_{11}	0.93572***	188.34616
b_{12}	-0.00807	-1.08727
b_{21}	0.01101***	5.70644
b_{22}	0.96624***	154.45013
d_{11}	0.26017***	9.87344
d_{12}	0.09535***	3.32089
d_{21}	0.03766**	2.01340
d_{22}	-0.08198**	-2.52875
$Q^2(10)$	47.09548 (P value: 0.20488)	
lnL	-4323.3749	

4) Volatility Spillover Effects between Australia REIT ETF and Japan REIT ETF

$Q^2(10)$ statistic in ⟨Table 6⟩ shows that there does not exist any ARCH effect in

14) Chen, L., "Quantitative Easing, Liquidity Spillover and Emerging Markets Inflation", *Finance and Economics*, 2011-10, pp.48-56.

squared residuals. Therefore, this bivariate GJR-BEKK-GARCH(1,1) model is successfully estimated.

As shown in ⟨Table 6⟩, b_{12} is not statistically significant, but b_{21} is statistically significant at the 10% level. This means that there exists unidirectional volatility spillover effect from Australia real estate market to Japan real estate market.

⟨Table 6⟩ GJR-BEKK-GARCH(1,1) model for Australia REIT ETF and Japan REIT ETF

This table reports the estimated results of the bivariate GJR-BEKK-GARCH(1,1) model for Australia REIT ETF and Japan REIT ETF. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: Australia REIT ETF, $r_{2,t}$: Japan REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.02472	0.93621
μ_2	0.07067***	3.19375
c_{11}	0.36815***	13.12255
c_{21}	-0.01352	-0.64582
c_{22}	0.34144***	30.41712
a_{11}	0.34972***	9.83284
a_{12}	0.04037***	3.14143
a_{21}	-0.05264*	-1.88118
a_{22}	0.41896***	22.62835
b_{11}	0.85033***	47.53070
b_{12}	0.01377	1.57399
b_{21}	0.02590*	1.80435
b_{22}	0.84753***	93.05983
d_{11}	0.42167***	13.93421
d_{12}	-0.03704**	-2.40602
d_{21}	-0.13674***	-3.73496
d_{22}	-0.23211***	-4.40548
$Q^2(10)$	36.71744 (P value: 0.61883)	
lnL	-3727.9042	

5) Volatility Spillover Effects between Australia REIT ETF and China REIT ETF

⟨Table 7⟩ GJR-BEKK-GARCH(1,1) model for Australia REIT ETF and China REIT ETF

This table reports the estimated results of the bivariate GJR-BEKK-GARCH(1,1) model for Australia REIT ETF and China REIT ETF. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: Australia REIT ETF, $r_{2,t}$: China REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.01807	0.72603
μ_2	0.02537	0.65197
c_{11}	0.38292***	19.95563
c_{21}	0.11360**	2.03573
c_{22}	0.17718***	5.15854
a_{11}	0.36599***	18.25450
a_{12}	-0.02703	-1.56590
a_{21}	0.03194**	2.02012
a_{22}	0.21825***	23.57606
b_{11}	0.84347***	77.36214
b_{12}	0.00846	0.56982
b_{21}	-0.01268*	-1.95081
b_{22}	0.96730***	346.35090
d_{11}	-0.38856***	-9.35368
d_{12}	-0.03072	-0.87668
d_{21}	0.03751	0.91967
d_{22}	0.08116***	2.98489
$Q^2(10)$	39.16021 (P value: 0.50790)	
lnL	-4289.5503	

$Q^2(10)$ statistic in ⟨Table 7⟩ shows that there does not exist any ARCH effect in squared residuals. Therefore, this bivariate GJR-BEKK-GARCH(1,1) model is adequately specified.

As shown in ⟨Table 7⟩, b_{12} is not statistically significant, but b_{21} is statistically significant at the 10% level. This means that there exists one-way volatility spillover effect from Australia REIT ETF to China REIT ETF.

⟨Table 7⟩ suggests that the volatility of Australia real estate market spills over to China, implying that Australia and China economies move closer since 2009.

6) Volatility Spillover Effects between Japan REIT ETF and China REIT ETF

$Q^2(10)$ statistic in ⟨Table 8⟩ shows that there does not exist any ARCH effect in squared residuals. Therefore, this bivariate GJR-BEKK-GARCH(1,1) model is adequately specified.

As shown in ⟨Table 8⟩, b_{12} is statistically significant at the 1% level, but b_{21} is statistically insignificant. This means that there exists one-way volatility spillover effect from China REIT ETF to Japan REIT ETF. This result indicates an increased influence of China on Japan in the real estate market.

⟨Table 8⟩ GJR-BEKK-GARCH(1,1) model for Japan REITs and China REITs

This table reports the estimated results of the bivariate GJR-BEKK-GARCH(1,1) model for Japan REIT ETF and China REIT ETF. ***, **, * denotes statistical significance at the 1%, 5% and 10% level, respectively.

mean equation :

$$r_{1,t} = \mu_1 + \epsilon_{1,t}$$
$$r_{2,t} = \mu_2 + \epsilon_{2,t}$$

where $r_{1,t}$: Japan REIT ETF, $r_{2,t}$: China REIT ETF

variance equation :

$$H_t = CC' + A\epsilon_{t-1}\epsilon'_{t-1}A' + BH_{t-1}B' + D\omega_{t-1}\omega'_{t-1}D'$$

	coefficient	t statistic
μ_1	0.06513***	3.14927
μ_2	0.04748	1.16613
c_{11}	0.29839***	20.96395
c_{21}	0.04936*	1.74618
c_{22}	0.20372***	12.96327
a_{11}	0.42801***	30.23485
a_{12}	-0.00040	-0.02485
a_{21}	0.02810**	2.38306
a_{22}	0.21101***	48.78744
b_{11}	0.84525***	197.76345
b_{12}	0.02012***	2.93870
b_{21}	-0.00227	-0.52292
b_{22}	0.96706***	1097.43200
d_{11}	0.17841***	4.48577
d_{12}	0.02597	0.65653
d_{21}	0.14851***	12.44402
d_{22}	-0.07545***	-3.18778
$Q^2(10)$	20.53605 (P value: 0.99542)	
lnL	-4195.1131	

V. Conclusions

This paper examines the volatility spillover among the U.S., and Asia-Pacific real estate market with Australia, Japan, and China REIT ETFs. REIT ETF has a unique characteristics in that REIT ETFs are traded on the stock market like stocks.

This sample period of this paper spans from 2010 to 2015. Thus, we can test the impact of the U.S. quantitative easing policy on Asia-Pacific real estate markets.

The evidence shows that there are strong volatility spillover effects, especially from the U.S. to Asia-Pacific real estate markets. In conclusion, Asia-Pacific real estate markets are exposed to the global macroeconomic conditions.

This study provides an useful information about global real estate investment when investors are looking for real estate market as an alternative investment vehicle during the period of low interest rates.

In this paper, the reason of volatility spillover among the U.S. and Asia-Pacific real estate isn′t explored. We believe that further research is needed to understand the spillover effects of real estate markets across the world. For further understanding about spillover effects among REIT ETFs, it is needed to take stock of capital flows, differential interest rates, or foreign exchange rate.

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