INTERNATIONAL VOLATILITY TRANSMISSION OF REIT RETURNS

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ABSTRACT

This study examines whether volatility of REIT returns can transmit across national borders. Two competing hypotheses are proposed. The first is the Transportable Risk Hypothesis which suggests geographic risk can be transmitted overseas if the general equity and real estate securities markets are integrated internationally. The second is the Non-Transportable Risk Hypothesis which argues that geographic risk factors are country-specific and therefore not transmittable across national borders. Using GARCH and EGARCH econometric models, international spillovers of volatility of REIT returns are found among United States, United Kingdom, and Japan. The finding has major implications for formulating international portfolio strategies as it improves forecasting ability. The finding also implies that better international portfolio diversification can be achieved with real estate securities from countries that have a lower degree of integration between the real estate sector and the general stock market.

JEL: C51**;** G11; G15

KEYWORDS: REIT volatility, multivariate GARCH, volatility spillovers, international portfolio diversification

INTRODUCTION

The progressive integration of international capital markets and the globalization of investor portfolios have provided the impetus to understand the dynamics of stock prices across national borders. Academic studies have found substantial evidence of transmission of stock returns volatility across international equity markets (e.g. King and Wadhwani (1990), Hamao, Masulis, and Ng (1990), Lin, Engle, and Ito (1994), Karolyi (1995), Bekaert and Harvey (1997)). The phenomenon of volatility transmission has also been found in currency markets (e.g. Melvin and Melvin (2003), Huang and Yang (2002), Kearney and Patton (2000)) and in futures markets (e.g. Gannon and Choi (1998), Franses et al. (1997), Najand et al. (1992)). Stevenson (2002) further documents the spillover of returns volatility from equity REITs to other classes of REITs in the United States. However, only few studies have investigated the spillover of volatility across international real estate securities. This study therefore examines the international transmission of REIT returns volatility using REITs of Japan, United Kingdom, and United States.

By applying Generalized Autoregressive Conditional Heteroscedasticity (GARCH) and Exponential GARCH (EGARCH) models, we find that there are significant international spillovers of REIT return volatility among the three countries. The geographic risk factors of a country affect volatility of REIT returns of other countries significantly. We also find that the volatility spillovers are symmetric. The negative news in one market does not increase volatility more than positive news in another market. Overall, our findings suggest that investors could benefit from international diversification by investing in real estate securities from countries that have a lower integration between their property sector and the general stock market.

The reminder of the paper is organized as follows. Section 2 summarizes relative literature about volatility spillovers across national markets and develops research hypotheses. Section 3 describes data selection, research methodology, and empirical models. Section 4 presents analysis and interpretations of the empirical findings. Section 5 concludes the paper.

LITERATURE AND HYPOTHESES

Financial markets around the world have become increasingly integrated over the past decade. Literature has documented that asset prices exhibit substantial co-movements internationally since. One strand of literature focuses on whether there is a market contagion across national markets. For example, King and Wadhwani (1990) analyze cross-market correlations between U.S., U.K., and Japan stock markets and find contagion effects are increased significantly after market crash in 1987. By using intra-daily data of New Your (S&P500 index) and Japan (Nikkie 225 Index), Lin, Engle and Ito (1994) suggest that information revealed in U.S. or Japan market could have a significant impact on the returns of the other market. Hamao, Masulis and Ng (1990) measure the interdependence of return and volatilities across international stock markets and find spillover effects in the returns and volatilities from the U.S. and the U.K. stock markets to the Japanese market are very strong, but the volatility spillovers from Japan to both U.S. and U.K. are not significant.In recent years, several studies also examine volatility transmission in multiple global markets. Ng (2000) examine the volatility spillovers from Japan and the US to Pacific–Basin equity markets and find both Japan and U.S. have significant impacts on market volatility in the Pacific–Basin region, although the effect of U.S. market is greater. Bekaert and Harvey (1997) analyze volatility in 20 emerging markets and find that increased market integration often increases the correlation between local market returns and the world market returns. Baele (2005) investigates volatility transmission from the aggregate European (EU) and U.S. market to 13 European equity markets and find high EU and U.S. Stock spillover intensity increased significantly over the 1980s and 1990s, and significant contagion effects from the U.S. to a number of local European markets in times of high equity market volatility. Diebold and Yilmaz (2009) examine return and volatility spillovers for 19 global markets and find volatility spillovers display no trend but clear bursts.

Another strand of literature focuses on whether asymmetries exist in the volatility transmission process. Bae and Karolyi (1994) examine Nikkie 225 index and S&P500 index return volatility and find asymmetric effect of good and bad news in a market. That is, bad news increasing volatility in one market has greater impact on volatility in the other market than good news. Koutmos and Booth (1995) also find similar results when they examine return and volatility spillover between U.S., U.K. and Japan markets. With real estate security data, Michayluk et al. (2006) document that asymmetric volatility transmission exists between U.K. and the U.S. real estate markets.

Although the volatility spillover in equity markets has been studied intensively, few papers have studied spillover of volatility across international real estate securities. Therefore, in this study, we examine whether real estate securities are globally integrated using REITs of Japan, United Kingdom, and United States. There are two competing hypotheses on this issue. We call the first hypothesis the Transportable Risk Hypothesis which states that geographic risk is transportable across national borders. This hypothesis is supported by many studies (e.g. Liu, et al. (1990), Mei and Lee (1994), Li and Wang (1995), Ling and Naranjo (1999)) that show REITs are integrated with common equities. If REIT and stock markets are truly integrated and that stock returns volatility can transmit internationally, then it is logical to assume that REIT returns volatility should also transmit internationally. The other hypothesis is the Non-Transportable Risk Hypothesis which states property markets are less integrated globally than general equity markets. Several studies (e.g. Asabere, Kleiman and McGowan (1991), Hudson-Wilson and Stimpson (1996)) evidence that the U.S. property markets are less globally integrated than the U.S. equity markets due to low positive correlations between U.S. real estate investment and international real estate equities. Gordon and Canter (1999), in explaining why there are considerable diversification benefits from an international real estate securities portfolio, suggest that it is because the revenues of most real estate securities remained closely tied to individual countries. Thus, cross-border influences are still of relatively low significance. As such, their explanation suggests that real estate securities should have low international transmission of returns volatility.

DATA AND METHODLOGY

We collect daily returns of the three REIT indices of United States, United Kingdom and Japan between Jan 1, 1999 and 2006 from the National Association of Real Estate Investment Trusts of the United States (NAREIT, www.reit.com). To be included in an index, the firm must be a closed-end company listed on an official stock exchange. In addition, the firm must meet specific geographic and financial standards. These standards in general request that the majority of earnings or bulk of total assets is the result of relevant real estate activity. Relevant real estate activities include the ownership, trading and development of income producing real estate. The majority of the earnings must also be derived from domestic operations. Such a requirement ensures no significant cross-correlations of the cash flows of the REITS of different countries. The company must also meet a minimum requirement regarding market capitalization. To investigate REIT returns volatility transmission among the three markets, we use both the GARCH and EGARCH models. The GARCH specification was developed by Bollerslev (1987) from the basic Autoregressive Conditional Heteroscedasticity (ARCH) procedures of Engle (1982). Both procedures have been found to perform remarkably well in modeling financial time series. These models allow for a time-varying conditional variance and that the conditional variance is modeled as a function of its past values as well as independent and/or exogenous variables. Specifically, the following GARCH (1, 1) specification is used.

$$R_{i,t} = \beta_{i,0} + \beta_{i,1} R_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

$$\sigma^2_{i,t} = \alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} \varepsilon^2_{j,t-1} + \gamma_i \sigma^2_{i,t-1} \quad for\ i, j = 1,2,3; \quad (2)$$

where $R_{i,t}$ is the daily REIT return series of country i, i=1,2,3 (i.e. 1 = United States, 2 = United Kingdom, and 3 = Japan) at time t, and $R_{i,t-1}$ is the daily REIT return series of country i, i=1,2,3 (i.e. 1 = United States, 2 = United Kingdom, and 3 = Japan) at time t-1. The time subscripts correspond directly to trading time but not necessarily to calendar time.

In the conditional variance equation, the variance of REIT returns depends on its own lagged value as well as the lagged squared residuals (innovations) of all the three countries. The lagged squared residuals in the equation are used for detecting volatility transmission across international boundaries. The EGARCH specification was developed by Nelson (1991). An advantage of EGARCH is that it is ideally suited to test the possibility of asymmetries in the volatility transmission mechanism because it allows own market and cross market innovations to exert an asymmetric impact on the volatility in a given market. In other words, news generated in one market is evaluated in terms of both size (i.e. the quantity) and sign (i.e. the quality) by other markets. Nelson (1991) finds that, for the US stock market, negative innovations increase volatility more than positive ones. Cheung and Ng (1992), Koutmos (1992), and Poon and Taylor (1992) all report evidence of the asymmetric impact of news shocks on volatility. The following EGARCH specification is also used in the study.

$$R_{i,t} = \beta_{i,0} + \beta_{i,1} R_{i,t-1} + \varepsilon_{i,t} \quad (3)$$

$$\sigma_{i,t}^2 = \exp\{\alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} f_j(z_{j,t-1}) + \gamma_i In(\sigma_{i,t-1}^2)\},\ \ for\ i,j = 1,2,3; \quad (4)$$

$$f_j(z_{j,t-1}) = \{|z_{j,t-1}| - E(|z_{j,t-1}| + \delta_j z_{j,t-1}\}, for\ \ j = 1,2,3; \quad (5)$$

$$\sigma_{i,j,t} = \rho_{i,j}\sigma_{i,t}\sigma_{j,t,}\ \text{for}\ i,j = 1,2,3,\ \text{and}\ i \neq j. \quad (6)$$

Equation (4) stipulates that the conditional variance of a country's REIT returns can be affected by volatility spillovers from the other two countries. Volatility spillovers across markets are measured by α_{ij} for i,j = 1,2,3 and i≠j. A significant α_{ij} coupled with a negative δ_j implies that negative innovations in market j have a higher impact on the volatility of market i than positive innovations, i.e. the volatility spillover mechanism is asymmetric. The γ_i in equation 4 measures the persistence of volatility.

EMPIRICAL RESULTS

The descriptive statistics in Table 1 shows that the REIT returns of UK and Japan are positively skewed while the REIT returns of US is negatively skewed. The kurtosis values of all the three returns series are much larger than three. This indicates that all the REIT returns series are leptokurtic and have fat tails relative to the normal distribution. All the three REIT returns series exhibit significant departure from normality, as indicated by the Jarque-Bera statistics, which reject the null hypothesis of normal distribution at the 1% significance level.

Table 1: Summary Statistics of REIT Index Returns

Statistics	US	UK	JP
Mean(μ)	0.0741	0.0558	0.0442
Median	0.0736	0.0438	0.0122
SD(σ)	0.7642	0.9167	2.1658
Skewness	-0.0090	0.0824	0.4284
Kurtosis	5.9775	6.1257	4.3038
Min.	-3.4527	-4.2778	-5.9254
Max.	4.7621	5.4135	10.2171
Jarque-Bera	370.5084	409.4431	101.7230
Probability	0.0000	0.0000	0.0000
ADF test at the Level I(0)[a]	-14.7216***	-13.1416***	-14.4086***

ljung-box q test results

Q-Statistics	US	UK	JP
A: Ljung-Box Q test for Autocorrelation of Raw Returns			
Lag(4)	25.310***	21.773***	5.745
Lag(8)	35.100***	23.430***	6.916
Lag(12)	35.734***	24.142***	10.524
Lag(16)	38.673***	27.686***	14.145
Lag(20)	41.950***	33.865***	17.925
Lag(24)	49.542***	36.380***	19.868
B: Ljung-Box Q test for Autocorrelation of Squared Raw Returns			
Lag(4)	338.41***	42.437***	1.640
Lag(8)	430.49***	47.550***	15.717**
Lag(12)	457.93***	49.338***	30.097***
Lag(16)	461.96***	66.208***	35.768***
Lag(20)	463.39***	76.864***	41.270***
Lag(24)	464.59***	78.868***	43.389***

*[a] The ADF test is Augmented Dickey-Fuller Unit Root Test. The ADF test is a test of stationarity. The critical values for ADF test are –2.5685, -2.8649, and –3.4396 for significance level of 10%,5%, and 1% respectively. ***,**, and * indicate significance at the 1, 5, 10 percent levels respectively.*

In addition to the above test, the Augmented Dickey-Fuller (ADF) test was conducted to check for unit root (stationarity) in order to determine whether the REIT returns need to be transformed before model estimation.

The ADF statistics strongly indicated that all the REIT returns are stationary. We reject the null hypothesis of unit root at the 1% level. The Ljung-Box Q test statistics indicate that the squared raw REIT returns have substantially higher autocorrelations than the raw returns. This indicates the presence of strong conditional heteroscedasticity in REIT returns. In short, statistical properties of the data strongly support the usage of GARCH and EGARCH models in this study.

Table 2 reports results of the GARCH (1, 1) model which allows for volatility transmission. The US and Japan stock markets open and close sequentially, as do the Japan and UK markets. There is no overlap in the daily open-to-close returns between US and Japan. Between UK and US, there is approximately a two-hour overlap. To simplify the analysis we assume that all three markets open and close sequentially. Non-overlapping trading implies that the estimation of the variances in each market is conditional on its own past information as well as information generated by the last two markets to close. In the estimation equations, $R_{i,t}$ is the REIT index return at time t for market i, (i =1, 2, 3, where, 1=US, 2=UK, and 3=Japan). The time subscripts in equation 1-2 correspond directly to trading time but not necessarily to calendar time. For example, if i =Japan, the time subscripts in equation 1-2 correspond directly to trading time , and the time subscripts also correspond directly to calendar time. If i =Japan, the information set for traders in Japan at the opening of the market in a given day includes past Japan innovations as well as innovations from US and UK in the previous day. Here, the trading time and the calendar time are consistent. But if i =US, the information set for traders in US at the opening of the market in a given day includes past US innovations as well as innovations from UK and Japan during the same day. In terms of trading time all this is past information (information set at t-1). But in terms of calendar time, US, UK and Japan are in the same day.

Table 2: Multivariate GARCH Model with Volatility Spillovers

From New York($\alpha_{3,1}$) & London ($\alpha_{3,2}$) to Tokyo		From Tokyo($\alpha_{2,3}$) & New York($\alpha_{2,1}$) to London		From London($\alpha_{1,2}$) & Tokyo($\alpha_{1,3}$) to New York	
$\beta_{3,0}$	0.0181 (0.0694)	$\beta_{2,0}$	0.0651 (0.0253)***	$\beta_{1,0}$	0.0802 (0.0208)***
$\beta_{3,1}$	0.0669 (0.0336)**	$\beta_{2,1}$	0.1230 (0.0360)***	$\beta_{1,1}$	0.0959 (0.0350)***
$\alpha_{3,0}$	0.1793 (0.0789)**	$\alpha_{2,0}$	0.0375 (0.0169)**	$\alpha_{1,0}$	0.0605 (0.0198)***
$\alpha_{3,1}$	-0.0446 (0.0234)**	$\alpha_{2,1}$	0.0265 (0.0154)*	$\alpha_{1,1}$	0.1700 (0.0361)***
$\alpha_{3,2}$	0.0045 (0.0232)	$\alpha_{2,2}$	0.1005 (0.0209)***	$\alpha_{1,2}$	0.0229 (0.0108)**
$\alpha_{3,3}$	0.0210 (0.0097)**	$\alpha_{2,3}$	0.0046 (0.0019)***	$\alpha_{1,3}$	0.0011 (0.0018)
γ_3	0.9440 (0.0224)***	γ_2	0.8122 (0.0371)***	γ_1	0.6698 (0.0704)***

$$R_{i,t} = \beta_{i,0} + \beta_{i,1} R_{i,t-1} + \varepsilon_{i,t}$$

$$\sigma_{i,t}^2 = \alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} \varepsilon_{j,t-1}^2 + \gamma_i \sigma_{i,t-1}^2, \text{ for i,j=1,2,3}$$

*Numbers in parentheses are standard error. ***, **, and *indicate significance at the 1, 5, 10 percent levels respectively.*

Results in Table 2 show that there are significant volatility spillovers from US to Japan (α_{31} =-0.0446) and UK (α_{21} = 0.0265) from Japan to UK (α_{23} = 0.0046) and from UK to US (α_{12} = 0.0229). That is, the findings support the Transportable Risk Hypothesis. Geographic risk factors of a country can affect volatility of REIT returns of other countries. Given that the REITs included in the NAREIT international indices are required to derive most of their earnings from domestic operations, it is therefore unlikely that the international transmission of REIT returns volatility is caused by correlated cash flows among the REITs. Hence, it appears that the reason for the volatility transmission is due to the integration of international REIT markets which makes possible the international transportation of geographic risk factors after they are securitized. Such an observation has major implications for investors who seek portfolio risk diversification by investing in international real estate securities. It appears that investors would get better diversification benefits by investing in countries that have a lower degree of integration between the general equity and real estate securities markets. Gordon and Canter (1999) find that some countries have a low correlation between the property securities and the broader equity market.

The persistence of volatility implied by equation 2 is measured by γ_1, γ_2 and γ_3. They are all significantly less than one, a result that is necessary for the unconditional variance to be finite. Persistence is strongest in Japan and least in US. This can be interpreted by using half-life concept, which measures the time it takes a shock to reduce its impact by one half. For UK the half-life is 3.33 days, for US half-life is 1.73 days, and for Japan half-life is 12.03 days. (Half-life for market i equals ln(0.5)/ln γ_i.)

Table 3: Diagnostic Statistics for the Standardized Residuals for the GARCH (1, 1) Spillover Model

Panel A: Diagnostic Tests			
	US	**UK**	**JP**
Skewness	-0.2337	0.0397	0.3733
Kurtosis	4.4499	5.0964	4.0013
Jarque-Bera	96.88	183.57	65.06
Probability	0.0000***	0.0000***	0.0000***
ARCH test p-value	0.6145	0.2939	0.2421
Panel B: Autocorrelation Q-statistics for Standardized Residuals			
Lag			
4	2.9736	4.2433	1.5175
8	6.5966	6.3539	3.0201
12	9.8177	6.3698	4.9647
16	12.430	9.2318	8.2920
20	16.494	15.012	11.704
24	25.599	17.727	13.076
Panel C: Autocorrelation Q-statistics for Standardized Residuals Squared			
Lag			
4	3.5972	1.1198	1.1621
8	4.7640	2.0885	6.4615
12	8.2988	4.9456	17.917
16	9.6303	11.010	19.335
20	16.238	21.494	21.800
24	20.774	27.291	27.623

****, **, and *indicate significance at the 1, 5, 10 percent levels respectively.*

Tablet 3 provides results of several diagnostic tests of the standardized residuals obtained from the multivariate GARCH model. The standardized residuals of UK and Japan are positively skewed, but the standardized residuals of US are negatively skewed. The kurtosis values are significantly larger than three for all countries, which indicate that the standardized residuals are leptokurtic and have fat tails relative to the normal distribution. Consequently, the Jarque-Bera normality tests reject the null hypothesis of normally distributed standardized residuals in all three countries. On the other hand, the ARCH-LM tests do not indicate the presence of a significant ARCH effect in all the three REIT returns series. This result suggests that the standardized residuals have constant variances and do not exhibit serial correlation. Panel B and panel C display the Ljung-Box Q statistics for the standardized residuals and squared standardized residuals at the 4^{th}, 8^{th}, 12^{th}, 16^{th}, 20^{th}, 24^{th} day lags. All the Q-statistics are insignificant. There is no autocorrelation in the standardized residuals and squared standardized residuals. The GARCH model therefore appears to provide a good parameterization of the three REIT returns series.

Table 4: Multivariate EGARCH Model with Volatility Spillovers

From New York($\alpha_{3,1}$) & London ($\alpha_{3,2}$) to Tokyo		From Tokyo($\alpha_{2,3}$) & New York($\alpha_{2,1}$) to London		From London($\alpha_{1,2}$) & Tokyo($\alpha_{1,3}$) to New York	
$\beta_{3,0}$	0.0432 (0.0681)	$\beta_{2,0}$	0.0614 (0.0266)**	$\beta_{1,0}$	0.0672 (0.0199)***
$\beta_{3,3}$	0.0533 (0.0312)*	$\beta_{2,2}$	0.1091 (0.0372)***	$\beta_{1,1}$	0.0848 (0.0370)**
$\alpha_{3,0}$	0.9966 (0.6169)*	$\alpha_{2,0}$	-0.2513 (0.0561)***	$\alpha_{1,0}$	-0.3774 (0.0669)***
$\alpha_{3,1}$	-0.0324 (0.0369)	$\alpha_{2,1}$	0.0238 (0.0148)*	$\alpha_{1,1}$	0.3055 (0.0584)***
$\alpha_{3,2}$	0.0082 (0.0387)	$\alpha_{2,2}$	0.2401 (0.0607)***	$\alpha_{1,2}$	0.0302 (0.0119)***
$\alpha_{3,3}$	-0.0088 (-0.1095)	$\alpha_{2,3}$	0.0055 (0.0020)**	$\alpha_{1,3}$	0.0027 (0.0040)
δ_3	0.0896 (0.0505)	δ_2	-0.0432 (0.0434)	δ_1	-0.0528 (0.0459)
γ_3	0.3621 (0.3930)	γ_2	0.8922 (0.0357)***	γ_1	0.8656 (0.0373)***

$R_{i,t} = \beta_{i,0} + \beta_{i,1} R_{i,t-1} + \varepsilon_{i,t}$

$\sigma_{i,t}^2 = \exp\left\{\alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} f_j(z_{j,t-1}) + \gamma_i In(\sigma_{i,t-1}^2)\right\}$, for $i,j = 1,2,3$;

$f_j(z_{j,t-1}) = \{|z_{j,t-1}| - E(|z_{j,t-1}| + \delta_j z_{j,t-1}\}, for\ j = 1,2,3;$

$\sigma_{i,j,t} = \rho_{i,j}\sigma_{i,t}\sigma_{j,t,}\ for\ i,j = 1,2,3, and\ i \neq j$

****, **, and *indicate significance at the 1, 5, 10 percent levels respectively.*

In Table 4, we report results of the EGARCH specification. Similar to the results of the GARCH model, we find strong evidence of international transmission of volatility of REIT returns. Specifically, there are significant volatility spillovers from US to UK (α_{21} = 0.0238), from Japan to UK (α_{23} = 0.0055), and from UK to US (α_{12} = 0.0302). The results are similar to those reported in Table 2 that there are significant volatility spillovers across the Atlantic, however, the volatility spillover from the Pacific only affects UK and does not reach US. The results again support the Transportable Risk Hypothesis. Moreover, the volatility spillovers are symmetric since the coefficients measuring asymmetry δ_3, δ_2 and δ_1 are not significant for all three markets. That is, negative news (innovations) in one market does not increase volatility more than positive news in another market. Asymmetry in volatility transmission is modeled by equation (5) and can be examined using its derivatives:

$$\partial f_j(z_{j,t}) / \partial z_{j,t} = 1 + \delta_{j,} \text{ for } z_j > 0$$
$$= -1 + \delta_{j,}, \text{ for } z_j < 0 \quad (7)$$

The size effect is measured by $|z_{j,t-1}| - E(|z_{j,t-1}|)$, and the corresponding sign effect is given by $\delta_j z_{j,t}$. If δ_j is negative, a negative $z_{j,t}$ tend to reinforce the size effect. If δ_j is positive, a negative $z_{j,t}$ tend to mitigate the size effect. The relative magnitude of asymmetry may be quantified by comparing the right-hand side of equation (7) when Z_j <0 and Z_j >0. It is found that conditional volatility of the REIT returns of UK and US also respond symmetrically to their own past innovations $\alpha_{1,1}$ and $\alpha_{2,2}$. The persistence of volatility implied by equation 4 is measured by γ_1, γ_2 and γ_3. They are all significantly less than one, a result that is necessary for the unconditional variance to be finite. Persistence is strongest in UK and least in Japan.

Table 5: Diagnostic statistics for the standardized residuals for the EGARCH (1, 1) Spillover Mode

Panel A: Diagnostic Tests			
	US	**UK**	**JP**
Skewness	-0.1985	0.0868	0.3611
Kurtosis	4.5422	5.0826	4.0505
Jarque-Bera	105.89	182.16	67.78
Probability	0.0000***	0.0000***	0.0000***
ARCH test p-value	0.4376	0.1494	0.0072***
Panel B: Autocorrelation Q-statistics for Standardized Residuals			
Lag			
4	3.1307	4.1611	2.1729
8	6.7404	6.1032	3.7364
12	9.3862	6.1143	7.2943
16	12.137	9.2288	11.122
20	16.276	14.991	14.268
24	26.792	17.703	15.796
Panel C: Autocorrelation Q-statistics for Standardized Residuals Squared			
Lag			
4	3.6778	1.8471	1.5068
8	4.9819	2.5334	18.481**
12	8.7433	5.1594	31.008**
16	9.8977	15.011	36.045***
20	18.690	25.335	39.728***
24	23.624	30.978	42.665**

****, **, and * indicate significance at the 1, 5, 10 percent levels respectively.*

Table 5 provides several diagnostic tests results of the standardized residuals obtained from the multivariate EGARCH model. Compared with multivariate GARCH model estimation, the results are similar except for Japan. The ARCH-LM test statistic is significant for Japan, indicating the presence of a significant ARCH effect for Japan. Some Q-statistics for squared standardized residuals are also significant for Japan, which suggest the presence of heteroscedasticity. Thus, we reject the null hypothesis of no autocorrelation in the squared standardized residuals for Japan. That is, the GARCH specification presents a better parameterization of REIT returns series for Japan than the EGARCH specification.

CONCLUSION

The purpose of this study is to examine whether volatility of REIT returns can transmit across national markets. More specifically, we examine the international transmission of REIT returns volatility among United States, United Kingdom, and Japan by using daily returns of the three REIT indices from NAREIT. Given the statistical properties of the time series data of the three REIT returns, GARCH (1, 1) and EGARCH (1, 1) models are used in the study to test volatility spillovers.

Our findings are summarized as follows. First, we find that the EGARCH model works better for US and UK REITs whereas the GARCH model is better for Japanese REITs. Second, the empirical results show that there are significant volatility spillovers from US to Japan and UK, from Japan to UK, and from UK to US. It indicates that significant international spillovers of REIT returns volatility exist among the three countries. This finding supports Transportable Risk Hypothesis, which indicates that geographic risk factors of a country can affect volatility of REIT returns of other countries. Third, the result of the

EGARCH model shows that the REIT returns volatility transmission is not asymmetric. That is, negative news does not affect volatility more than positive news.

Our findings are consistent with the implication that the real estate sector and the general equity market are integrated in the three countries. An important implication for investors is that they would get more portfolio risk diversification benefits by investing in real estate securities from countries that have a lower integration between their property sector and the general stock market. The volatility transmission literature has yet to develop a comprehensive theory to explain the observed results of empirical studies. Nevertheless, the results of our study show that a general understanding of the relationship between international real estate securities markets movements has a practical use for formulating international portfolio strategies as it improves forecasting ability.

Even though our results show significant volatility spillovers among those markets, there are some limitations in our study. First, our results are based on the evidence of three major REIT markets from developed countries. Second, readers need to be aware of that the volatility effect we present in this paper could be time-varying and such relation could be changed due to regime switch or market shock. Future studies might consider including other REITs, particularly REITs from emerging markets to verify whether our findings hold.

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