The Impacts of the 2008 and 2011 Crises on the Japan REIT Market

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The Japan REIT Market: Impacts from the 2008 and 2011 Crises

by

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Abstract

This empirical paper studies the impact of real estate and stock price shocks on the J-REIT prices from the 2008 financial crisis and the 2011 Japan earthquake for the period between May 2003 and December 2014. Four VAR models incorporating different data scenarios are applied to see whether the two crises produce a temporary, permanent or converging impact. The results show that the real estate price mainly affects the J-REIT price, but the stock price shock affects the J-REIT price temporarily during the 2008 crisis and the 2011 earthquake. After the 2011 earthquake, the real estate price shock overcomes the stock price shock of the 2008 crisis on J-REIT price. The findings suggest to international investors that the long-run investments on the J-REIT should depend on the real estate price in Japan.

Keywords: Global Financial Crisis 2008; Great Earthquake 2011; Dynamic Effects; J-REIT prices; Stock price; Housing price, CC-EGARCH.

JEL Classification Numbers: G01; G12; O16

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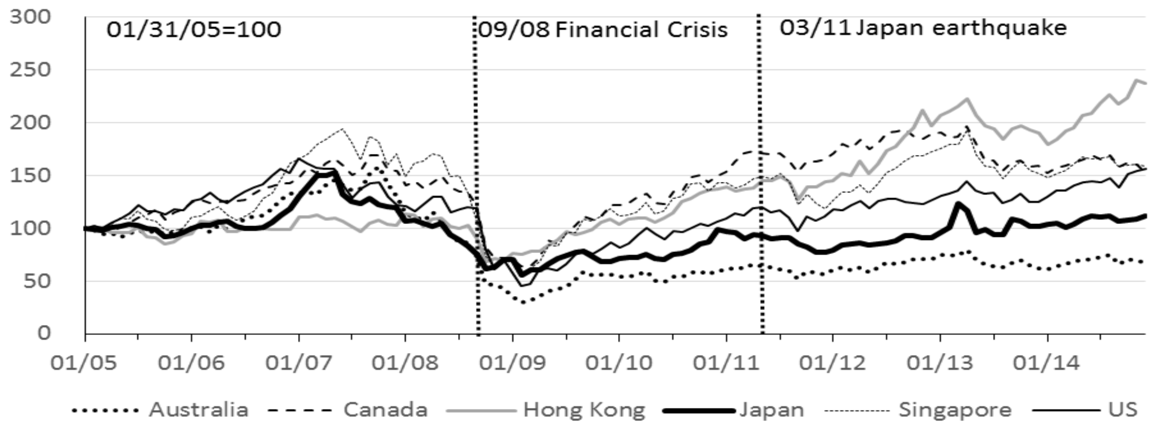
1. Introduction

The Real Estate Investment Trust (REIT) provides to its beneficiaries a stream of income derived from rents with long contracts that work similar to real estate ownerships. Since the REIT can diversify its risk in various trust funds traded in the market, the REIT effectively incorporates the merits of stock investment into real estate investment. The price of REIT is literally known as the hybrid price (Giliberto, 1990). The determinants of the REIT price have extensively been studied, especially the impact on the REIT price from the stock market or the real estate market. Studies by Peterson and Hsieh (1997), Karolyi and Sander (1998), and Ling *et al*. (2002), for example, showed that the stock price has a stronger effect on the REIT price than the real estate price. In the case of the US, Barkham and Geltner (1995) used Granger-causality to show that the real estate price cannot be the determinant of the REIT price. In addition, Redman and Manakyan (1995) found from investments in western United States that healthcare properties are the most significant variable in explaining the REIT return. In studying the effect of changeable determinants, Clayton and Mackinnon (2003) implemented the variance decomposition of the REIT returns in 1993-1998 by employing a rolling regression that separates the REIT return variability into components directly related to major stock, bond, and real estate-related return indices.

In relation to the 2008 global financial crisis, Case *et al*. (2012a, 2012b) studied the effect of 2008 crisis on REIT's dividend policy in US markets. Chang and Chen (2014) examined evidence of contagion in global REITs returns over the period 2006–2010 using daily REITs indices for 16 countries. The 2008 crisis that triggered by the 'subprime loan' shock in the housing markets changed the financing method. Indeed, beginning from the 1990s when the US-REIT was developed, there has been a lack of evidence on real estate shock on the REIT price, except in Kallberg *et al*. (2008) whom studied the New York REITs in response to the catastrophic events of September 11, 2001, and revealed that on the day when markets reopened, the REITs with significant exposure to the New York area outperformed the broader REIT office index by 4.1 %, and it lasted till mid-November before the abnormal REIT returns disappeared.

On the contrary, the Great Earthquake in Japan with a recorded magnitude scale of 9.0 on March 11, 2011, had negatively affected Japan's real estate market, as many properties were destroyed by the tsunami, especially the cities located along the eastern oceanfront. Although such a natural disaster occurred only every 200-300 years in Japan, the 2011 earthquake crisis could provide a comparative event study on the REIT prices with situations in other countries. Figure 1 shows that although the Japanese REIT (J-REIT) made a quick recovery after the 2008 crisis, its price dropped and stayed low when compared to the prices of other REITs in US, Singapore and Hong Kong. The J-REIT market was the only world market that experienced the two shocks in 2008 and 2011.



Source: MSCI ACWI REIT Index Fact Sheet.

Figure 1 The REIT Indices Compared

This paper presents an event-study on both the 2008 and 2011 shocks in the J-REIT market in three aspects: i) the effect of real estate price and stock price on the J-REIT price; ii) the impact structure after the two shocks, and iii) whether the impacts are temporary, permanent or converge during the sample period from May 2003 to December 2014. The first two aspects will be useful to international property investors and policy-makers as they might be interested in the J-REIT after the 2011 earthquake. For example, whether the REIT price would be dominated by real estates that faced the impact of earthquake tsunami or by the stock price could be an interesting decision for the investors. Indeed, the decrease in real estate price as a result of the earthquake tsunami would delay the recovery of the J-REIT prices (as shown in Figure 1), despite of the increase of stock price (as shown in Figure 3-(a)) when compared to other markets. The third aspect will show whether the shock is permanent or temporary. If the shock has a permanent effect, the J-REIT price would not have a positive recovery sign (as one can see from Figure 3-(a)).

Section 2 briefly reviews the development of the J-REIT markets since 2001. Section 3 describes the econometric methodology. Section 4 describes the data and presents preliminary analyses. Section 5 reports the empirical results and examines how the real estate price and the stock price are affecting the REIT prices from the two events in 2008 and 2011. Section 6 shows the robustness checks by using global variables and the total return data that included dividend data. Section 7 presents the concluding remarks.

2. Overview of the J-REIT Markets

The J-REIT was first listed in September, 2001, in the Tokyo Stock Exchange, and by March 2014, a total of 42 J-REITs were listed. As of November, 2014, the scale of Japan's REIT market has become the biggest in Asia, and is the world's third largest in the amount of outstanding (see Table 1). The share of the US-REIT in the world reached 60.2% at the end of November 2014, which surpassed the second largest of Australia (6.3%) and the third of Japan (6.1%). The world's largest eight REITs occupied 93% of the world total, as shown in Table 1.

Similar to other world REITs, the J-REIT has various types of real estates in its portfolio. We can classify it into the specialized type that includes offices, houses, commercial facilities and hotels, and the unified or composite type that includes several kinds of real estates based on assets holding. All major REIT countries shown in Figure 1 have experienced a drastic fall in the REIT prices after the 2008 crisis (Lehman shocks), but the REIT prices had quickly recovered in Singapore and Hong Kong and even in the US. The J-REIT price, however, was under further attack after the 2011 earthquake and remained stagnant.

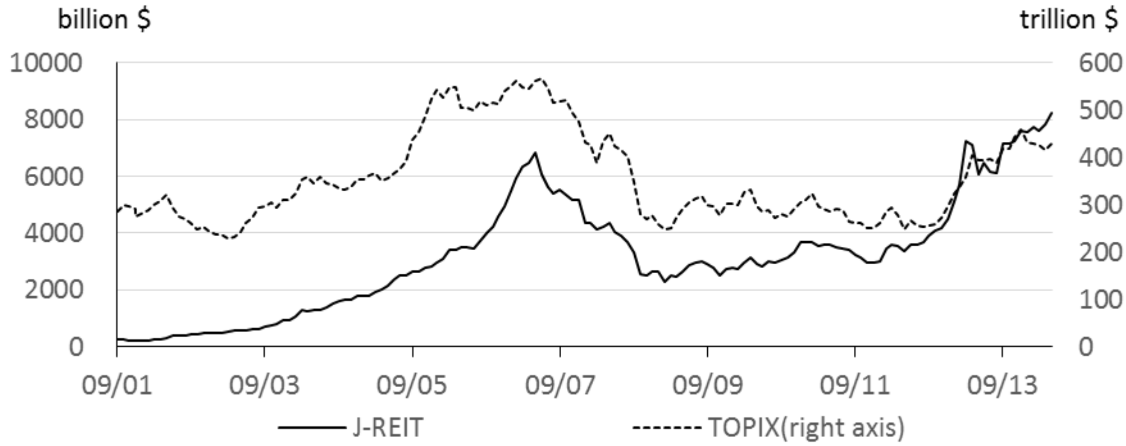
Table 1 REITs Outstanding in the World Market (End of November, 2014)

Order	Country	Number of REITs	Market Capitalization (US$ million)	World Ratio (%)
1	USA	231	825,493	60.2
2	Australia	52	86,169	6.3
3	Japan	46	84,100	6.1
4	France	33	75,041	5.5
5	UK	22	66,069	4.8
6	Canada	49	55,549	4.0
7	Singapore	37	52,049	3.8
8	Hong Kong	12	26,812	2.0
	Others	183	100,493	7.3
	Total	665	1,371,775	100.0

Source: MSCI ACWI REIT Index Fact Sheet.

Figure 2(a) shows the fluctuation in the market capitalization between the J-REIT market and the total stock market in the 1st Section of the Tokyo Stock Exchange. For the fifteen years from 2001 to 2015, market capitalization has achieved over 9 trillion Japanese yen, while the ratio of the J-REIT market to TOPIX has remained at 2.5%, which could have been constrained by the 2008 and 2011 events. On the other hand, Figure 2(b) shows the ratio between the J-REIT market capitalization and all stocks for TOPIX as well as the stock capitalization of real estate companies. Despite the two crises in 2008 and 2011, the REIT/real estate companies' ratio has gradually increased to approach 80%, which has become almost the same size as the real estate stock market. In general, the fifteen years of development has led to growth in the J-REIT market.

(a) Market Capitalization of J-REIT and TOPIX

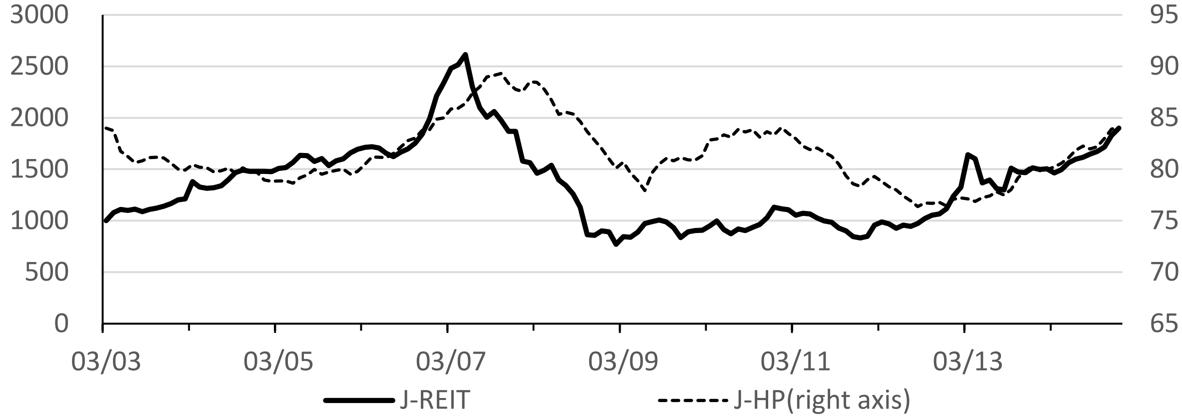


(b) Fluctuation in the Ratio of J-REIT Market Capitalization to Real Estate Companies

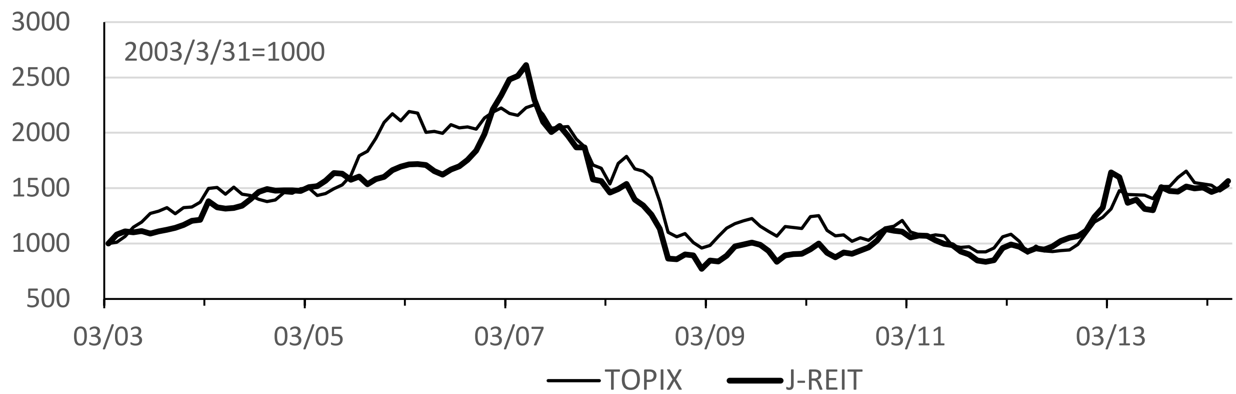
Sources: ARES J-REIT Databook (http://j-reit.jp/statistics/) for Market Capitalization of J-REIT; Web site of the Tokyo Stock Exchange for Market Capitalization of the Tokyo Stock Exchange (http://www.jpx.co.jp/English/markets/statistics-equities/misc/02.html); and NEEDS Financial Quest for Market Capitalization of Real Estate Companies' Stock Market.

Figure 2 The J-REIT Market Performance

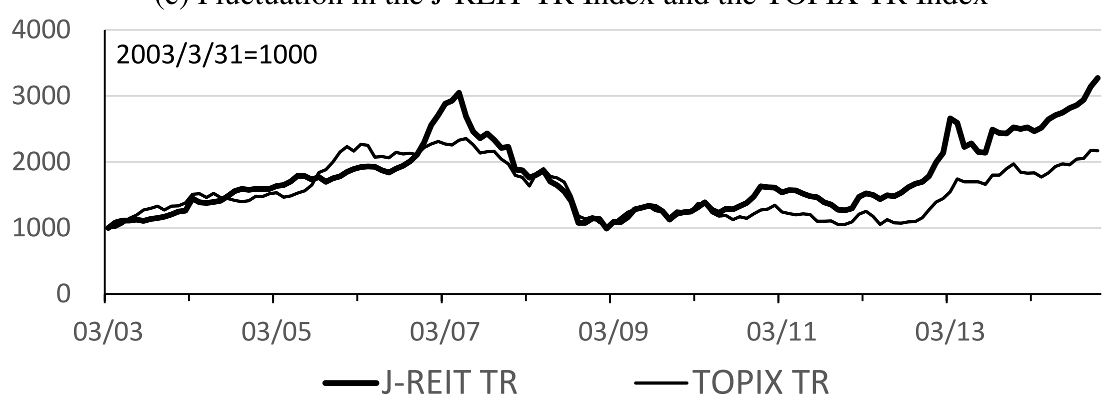
(a) Fluctuation in the J-REIT Price Index and the J-Housing Price Index



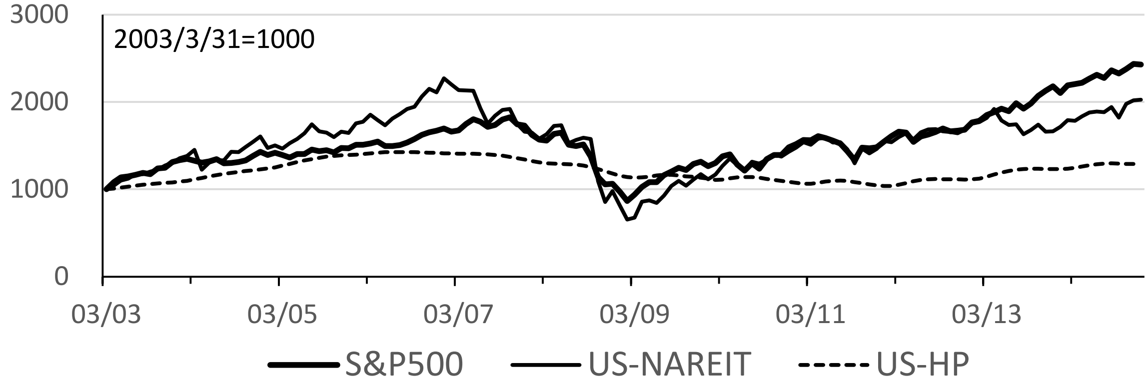
(b) Fluctuation in the J-REIT Price Index and the TOPIX



(c) Fluctuation in the J-REIT TR Index and the TOPIX TR Index



(d) S&P500, US-NAREIT Price Index and Case-Shiller U.S. National Home Price Index



Sources: ARES J-REIT Databook (http://j-reit.jp/statistics/) for J-REIT Price Index and J-REIT Total Return index (including dividend); Japan Real Estate Institute (http://www.reinet.or.jp/?page_id=14347) for Japan Housing Price Index;[1] NEEDS Financial Quest for TOPIX and TOPIX Total Return. S&P Capital IQ for S&P500; REIT.com for US-NAREIT Price Index (https://www.reit.com/investing/index-data/monthly-index-values-returns); and Web page of S&P Dow Jones Indices for Case-Shiller U.S. National Home Price Index (http://us.spindices.com/indices/real-estate/sp-case-shiller-us-national-home-price-index).

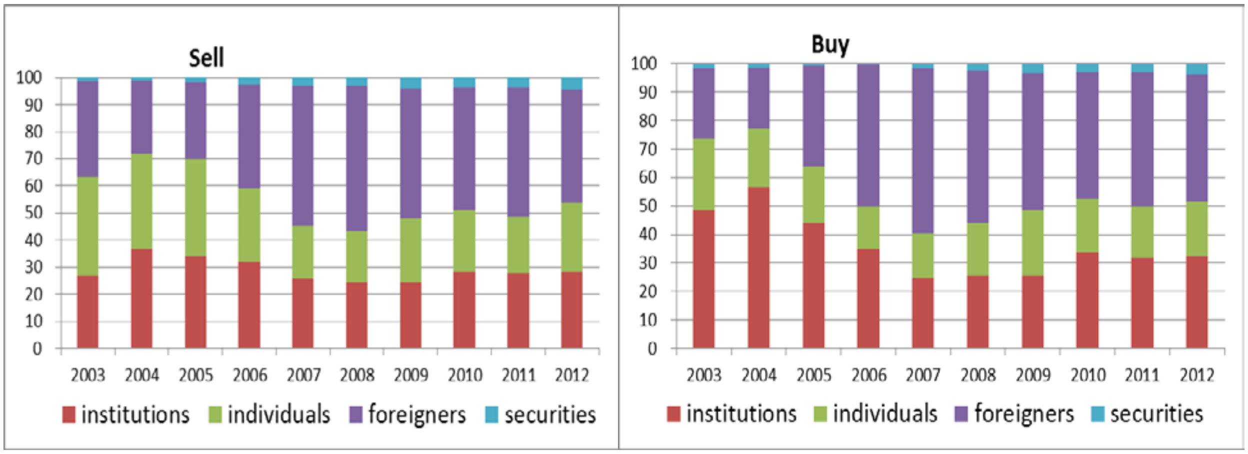
Figure 3 The J-REIT and Other Indices

Figure 3(a) shows a similar fluctuation between the J-REIT Price Index and the Japan Housing Price (J-HP) Index, but the trend is different between the J-REIT Price Index and the TOPIX as shown in Figure 3(b). However, when examined closely, it is expected that the J-REIT should show similar fluctuations to at least one of J-HP Index and TOPIX during some periods. Figure 3(c) illustrates the J-REIT Total Return (J-REIT TR) Index and the TOPIX.Total Return (TOPIX TR), which include data on dividends. Case *et al*. (2012a, 2012b) and Milunovich and Truck (2013) used similar data to explain the REIT markets. Hence, we shall implement the robustness check by using the price index and the total return index (the dividend yield) shown in Figure 3(a), 3(b) and 3(c). Both indexes increased after the 2008 crisis, but they both shrank and decreased after the 2011 earthquake. Figure 3(d) shows the US-REIT related data: S&P500 as stock price, US-NAREIT Price as US-REIT and Case-Shiller U.S. National Home Price as housing price. Studies by Peterson and Hsieh (1997), Karolyi and Sander (1998), Ling *et al*. (2002) and Barkham and Geltner (1995) suggested, as shown in Figure 3(d), that S&P500 and US-NAREIT Price behaved similarly to each other, while Case-Shiller U.S. National Home Price behaved differently. We believe that these data can serve as exogenous variables for J-REIT.

Figure 4 shows the fluctuation in the J-REIT investment trends by investor categories. In the ten years (2003-2012), trading by foreigners exceeded over 50% of total, while individuals become a minority trader

[1] The Japan Housing Price Index issued by the Japan Real Estate Institute is the former Tokyo Stock Exchange Home Price Indices.

since 2007 with less than 30% in both sell and buy figures. As such, we have to incorporate the viewpoints of international traders by using the foreign REIT price (e.g. US-REIT). The studies by Ling *et al*. (2002), Hamelink and Hoesli (2004) and Bond *et al*. (2004) found that an international real estate and country-specific factors remain important. [2]



Source: Web page of Tokyo Stock Exchange ("Trading by Type of Investors", http://www.jpx.co.jp/english/markets/statistics-equities/investor-type/03.html).

Figure 4 J-REIT Investment Trends by Investor Categories
(% in commissioned trading measured in yen)

Finally, following the work in previous studies, we also use the housing (residential) price as the proxy for the real estate price that could determine the REIT price. The property investment portfolio of J-REIT included offices, warehouses, hotels, residential, retail, healthcare, or diversified (including office, residential, retail) properties. However, the December 2014 statistics shows that J-REIT's investment in residential property occupied about 15% of the market value of all categories.[3] Out of the total of 49 J-REIT companies, 8 companies have focused on investment in residential property, while 14 companies have invested in diversified property which also includes residential property.[4] On the other hand, the December 2014 statistics show that the investment by US-REIT in residential property comprised only 12% in market value.[5]

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[2] Ling *et al*. (2002, p.119) pointed out that the REIT provided a vehicle for investors to construct international commercial real estate portfolios without the burden of acquiring, managing, and disposing direct property investments in far-away countries with unfamiliar legal, political, and market structures.

[3] ARES·J-REIT DIGEST, p.3, Jan/2015. http://j-reit.jp/brand/digest.html, The Association for Real Estate Securitization. (in Japanese).

[4] Real Investment Trust Data Portal (List of J-REIT), http://en.japan-reit.com/list/rimawari/ , Japan REIT Inc.

[5] NAREIT: REIT Watch, December 2014, p.4, 106,186,441/(805,467,256 + 65,666,368)＝12%, National Association of Investment Trust.

3. Econometric Methodology

To examine quantitatively the dependency (co-movement) of the J-REIT price on the stock price and the real estate price expressed in logarithm form, we assume that the data used in $Y_t = \left(y_{1,t},\ \cdots, y_{3,t}\ \right)'$ are possibly generated from a nonstationary VAR(p) model with constant terms of A_0, Γ, Φ, the exogenous variables $\Delta X_{t-1} = \left(\Delta x_{1,t-1},\ \cdots, \Delta \mathrm{x}_{3,t-1}\ \right)'$ and Gaussian errors ε_t:[6]

$$Y_t = A_0 + \sum_{i=1}^{p} A_i\ Y_{\mathrm{t\text{-}i}} + \Phi \Delta X_{t-1} + \varepsilon_{\mathrm{t}},\ \ t = 1, \cdots, T. \tag{1}$$

Equivalently expressed in an error correction form, the model becomes:

$$\Delta Y_t = A_0 + \sum_{i=1}^{p-1} \Gamma_i\ \Delta Y_{\mathrm{t\text{-}i}}\ + \Pi\ Y_{\mathrm{t\text{-}i}} +\ \Phi \Delta X_{t-1} + \varepsilon_{\mathrm{t}}, \tag{2}$$

where $\Pi = I - \sum_{i=1}^{p} A_i$ and $\Gamma_i = -\sum_{j=i+1}^{p} A_j$ $\left(\mathrm{i} = 1, ..., \mathrm{p} - 1\right)$. Johansen (1991) showed that if Y_t is cointegrated, the coefficient matrix Π has a reduced rank of r and can be represented as $\Pi = \alpha \beta^{'}$, where α and β are $n \times r$ matrices. We test the rank of Π in order to determine the precise data generating process.

On the basis of preliminary analysis for cointegration ('non-cointegration' shown in Appendix 1), we apply the following data generating process that consists of the J-REIT price return on the stock price return and the real estate price return:[7]

$$\Delta Y_t = A_0 + \Gamma_1\ \Delta Y_{\mathrm{t\text{-}1}}\ + \Phi \Delta X_{t-1} + \varepsilon_{\mathrm{t}}.\ \ \mathrm{t} = 1, \ldots, \mathrm{T}. \tag{3}$$

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[6] The J-REIT price will be given by the discounted sum of future cash flows of real estate. The future cash flows are generally affected by the past housing price index and stock price index, which are assumed to be a linear function of those variables for the sake of manipulation sense. There are other factors affecting the J-REIT price, though these are included in stochastic term. Therefore, most empirical papers in time series analysis for stock markets use VAR model. Similarly, since the majority of traders in the J-REIT market is US investors whose future cash flows will be affected by the past US-REIT, US-Stock and US-Housing prices.

[7] The Augmented Dickey–Fuller (ADF) tests for a unit root show that all data are I(1) processes. The Schwartz Information Criterion (SIC) indicates a lag length of p = 2 in (1). There are no cointegration relationships, which is resulted from the Max-Eigen Value test. Moreover, for any lag length p=2, 3, 4, and 5, there are no cointegration relationships. Based on these observations, we apply the model in equation (3). See Appendix 1.

The error term ε_t follows a multivariate EGARCH model with *constant* conditional *correlation* (CC) proposed by Bollerslev (1990) as $\varepsilon_t | \Omega_{t-1} \sim N(\mathbf{0}, \mathbf{H}_t)$, where Ω_{t-1} denotes the information set up to time t – 1. The variance–covariance matrix ($\mathbf{H}_t$) is factorized into the product of variance and correlation matrices:

$$\mathbf{H}_t = \mathbf{D}_t \mathbf{R} \mathbf{D}_t, \quad \mathbf{R} = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix}, \quad \mathbf{D}_t = \begin{pmatrix} \sqrt{h_{11,t}} & 0 & 0 \\ 0 & \sqrt{h_{22,t}} & 0 \\ 0 & 0 & \sqrt{h_{33,t}} \end{pmatrix}, \tag{4}$$

where $\mathbf{D}_t = diag\left(h_{11,t}^{1/2}, \cdots, h_{33,t}^{1/2}\right)$ is a diagonal matrix of variances, and $\mathbf{R}$ is an 3×3 constant correlation matrix.[8] The conditional variance of the *i*th element follows a univariate EGARCH model as explored in Nelson (1991):

$$\begin{aligned} &\log(h_{ii,t}) = \alpha_{i0} + \alpha_{i1}(|u_{i,t-1}| - E(|u_{i,t-1}|)) + \alpha_{i2} u_{i,t-1} + \beta_{i1} \log(h_{ii,t-1}) \\ &\text{where } u_{i,t-1} = \varepsilon_{i,t-1} / \sqrt{h_{ii,t-1}} \quad \text{for } i = 1,2,3 \end{aligned}, \tag{5}$$

where $\alpha_{i2} < 0$ shows asymmetrical effects.

The CC-EGARCH approach can be summarized as follows. The conditional variance is formulated in Equation (5), and the constant correlation coefficients are formulated in Equations (4).[9] Using the conditional variance and the constant correlation coefficients yields the conditional variance covariance matrix ($\mathbf{H}_t$). The maximum likelihood method is applied to estimate the correlation coefficients ρ, the conditional variance $\alpha_{i0}, \alpha_{i1}, \alpha_{i2}, \beta_{i1}$ $for\, i = 1,2,3$, and additional parameters in the mean equations in Equation (3). The full set of parameters for both the mean equations in Equation (3) and the multivariate CC-EGARCH specification in Equation (4) and Equation (5) is denoted by θ. Based on a sample of size T, the log-likelihood function L is

$$L(\theta; \Delta Y_1, \ldots, \Delta Y_t) = -\frac{1}{2} \sum_{t=1}^{T} \left\{ \log(2\pi) + \log\det(H_t) + \varepsilon_t H_t^{-1} \varepsilon_t' \right\}. \tag{6}$$

We calculate several coefficients using the CC-EGARCH model. The sequence of verification is shown as follows:

[8] We found that the estimated ρ_{12}, ρ_{13} and ρ_{23} yield the positive definite of conditional covariance matrix, H_t.

[9] The dynamic conditional correlation (DCC) proposed by Engle (2002) was applied, but we found that the correlation was not dynamic but constant. These results are not shown in the text.

1. In Section 4, we describe the statistics of the data and their sources. Tables 2 and 3 report the results.
2. In Section 5.1, we use the maximum likelihood method, include $\Phi = 0$ in Equation (3) and estimate the parameters of θ for the CC-EGARCH model in Equation (7). The results are reported in Table 4 for causality between the J-REIT, stock and real estate. The results for causality show the determinants of the J-REIT.
3. As the main interest is the impact of the 2011 earthquake on J-REIT, we include in Section 5.2 the dummy variables of September 2008 or March 2011 at Γ_1 in Equation (3), estimate their coefficients using Equation (8) and investigate the impact of the 2011 earthquake on the causality between the J-REIT, stock and real estate markets. The dynamic effects are investigated by comparing the estimates for the pre-2008 period, the 2008 crisis, the 2011 earthquake, and the post-2011 period. The results are reported in Tables 5 and 6.
4. The robustness checks are conducted by including exogenous variables X_{t-1} for Φ in Equation (3) based on such global variables as the US REIT and estimated the coefficients in Equation (9). The results are reported in Table 7.
5. Other robustness checks are also conducted by using Total Return Index for all variables in Equation (9). The results are reported in Table 8.

4. Data Description and Preliminary Analysis

The monthly data comprise of the J-REIT index, the TOPIX and J-Housing Prices index for the period between May 2003 and December 2014. We also consider the US-NAREIT Price Index, S&P500 and US-Housing Prices for Case-Shiller U.S. National Home Price Index as global variables. We use the following notation.

$\Delta y_{1,t}$: J-REIT price index return at time t;

$\Delta y_{2,t}$: TOPIX return at time t;

$\Delta y_{3,t}$: J-Housing Price index return at time t;

$\Delta x_{1,t}$: US-REIT Price index return at time t;

$\Delta x_{2,t}$: S&P500 return at time t; and

$\Delta X_{3,t}$: US-Housing Price index return at time t.

All variables are logarithmic differenced. Figures 3(a) to 3(c) show the data for the J-REIT price index, TOPIX, J-Housing price (J-HP) index, respectively. The exogenous variables of US-REIT price index, US-Housing price (US-HP) index and S&P500 are shown in Figure 3(d). We observe the following characteristics: (i) all variables have changed along with each other over time; and (ii) all variables fluctuated more wildly during the global financial crisis in 2008–2009, while only the Japanese variables (J-REIT index, TOPIX, J-HP index) fluctuated more wildly during the 2011 earthquake though they all dropped afterwards. Table 2 reports the descriptive statistics for the price index returns, shown as: $\Delta Y_t = \left(\Delta y_{1,t},\ \Delta y_{2,t},\ \Delta y_{2,t}\right)'$, and confirms the stylized facts on asset return in the form of highly significant skewness, high kurtosis, and significant autocorrelations in squared yields. Table 3 shows the contemporaneous unconditional correlations between the different returns. The order of the three market returns are shown according to the degree of correlation with the J-REIT market returns. The TOPIX return has the highest correlations, while J-HP index return has lower correlations.

Table 2 Descriptive Statistics for the Price Index Returns

	Mean	Std. dev	Skew	Kurt	Min	Max	Q(4)	Q(4)-2
J-REIT Price index	0.45	5.98	-0.73	4.14	-27.08	21.63	10.18*	9.36*
TOPIX	0.41	5.25	-0.73	2.11	-22.64	11.87	15.31*	7.11
J-HP index	0.00	0.73	-0.08	0.27	-2.38	2.18	40.18*	2.66

Notes: Q(4) denotes the Ljung–Box statistic with four lags for the log-difference variable, and Q(4)-2 denotes the corresponding statistics for the squares of those variables. The 10% critical value of the Q(4)-statistic is 7.78.

Table 3 Contemporaneous Unconditional Correlations between Price Index Returns

	J-REIT Price index	TOPIX	J-HP index
J-REIT Price index	1.00		
TOPIX	0.63	1.00	
J-HP index	0.19	0.18	1.00

5. Empirical Results

5.1. Parameter Estimates and Conditional Correlations

Based on the preliminary analysis shown above, we estimate a VAR model from Equations (4), (5) and (7), shown as:

$$\Delta Y_t = A_0 + \Gamma_1 \Delta Y_{t-1} + \varepsilon_t, \qquad \varepsilon_t \left| \Omega_{t\text{-}1} \sim N\left(0, H_t\right). \right. \tag{7}$$

The parameters are γ_{11}(J-REIT to J-REIT), γ_{12}(TOPIX to J-REIT) and γ_{13} (J-HP to J-REIT) .[10] The results in Table 4 reveal the first finding that all the estimated EGARCH terms, α_{11}, α_{12} and β_{11} in Equation (5) are significant and also the constant conditional correlations ρ_{12}, ρ_{13} and ρ_{23} in Equation (4) are significant.[11] Moreover, when compared to the alternative model, namely the Dynamic Conditional Correlation-EGARCH (DCC-EGARCH), we found that the dynamic conditional correlations for $\rho_{12,t}, \rho_{13,t}$ and $\rho_{23,t}$ are constant over time by using both statistical test and visual inspection (not shown in the paper). This implies that the CC-EGARCH specification is valid for modeling price index returns in the J-REIT markets. The results in Table 4 reveal the findings for causality. The significant-effects on the J-REIT and the significant-causality between J-REIT and J-HP index, $\gamma_{13} > 0$, is shown at 5% significance level. This finding differs from the US-REIT determinants (Barkham and Geltner, 1995; Peterson and Hsieh, 1997; Karolyi and Sander, 1998; Ling *et al*., 2002).[12]

Table 4 Parameter Estimates of CC-EGARCH Model

	γ_{11}	γ_{12}	γ_{13}	α_{11}	α_{12}	β_{11}	ρ_{12}	ρ_{13}	ρ_{23}
REIT	0.150*	0.101	1.948**	0.559**	0.184**	0.852**	0.630**	0.169**	0.153**
	(0.090)	(0.083)	(0.601)	(0.161)	(0.087)	(0.062)	(0.052)	(0.075)	(0.071)

Note: The estimated VAR model (with CC-EGARCH) is:

$$\Delta Y_t = A_0 + \Gamma_1 \Delta Y_{t-1} + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \left| \Omega_{t-1} \right. \sim N\left(\mathbf{0}, \mathbf{H}_t\right),$$

$$\Gamma_1 = \begin{pmatrix} \gamma_{11}, & \gamma_{12}, & \gamma_{13} \\ \gamma_{21}, & \gamma_{22}, & \gamma_{23} \\ \gamma_{31}, & \gamma_{32}, & \gamma_{33} \end{pmatrix}, \ \mathbf{H}_t = \mathbf{D}_t \mathbf{R} \mathbf{D}_t, \ \ \mathbf{R} = \begin{pmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{12} & 1 & \rho_{23} \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix}, \quad \mathbf{D}_t = \begin{pmatrix} \sqrt{h_{11,t}} & 0 & 0 \\ 0 & \sqrt{h_{22,t}} & 0 \\ 0 & 0 & \sqrt{h_{33,t}} \end{pmatrix}$$

$$\log(\mathrm{h}_{\mathrm{ii,t}}) = \alpha_{\mathrm{i}0} + \alpha_{\mathrm{i}1}(|u_{\mathrm{i,t-1}}| - E(|u_{\mathrm{i,t-1}}|)) + \alpha_{\mathrm{i}2} u_{\mathrm{i,t-1}} + \beta_{\mathrm{i}1} \log(\mathrm{h}_{\mathrm{ii,t-1}})$$

$$\text{where } \mathrm{u}_{\mathrm{i,t-1}} = \varepsilon_{\mathrm{i,t-1}} / \sqrt{\mathrm{h}_{\mathrm{ii,t-1}}} \quad \text{for } \mathrm{i} = 1,2,3$$

Notes: The three parameters, γ_{11}, γ_{12} and γ_{13}, denote respectively the coefficients for the J-REIT, TOPIX, and J-HP index in the above equation. Standard errors are in parentheses. * and ** are significant at 10% and 5% level, respectively. The estimated γ_{12} denotes non-significance at 5% level, while almost all estimates of $\gamma_{11}, \gamma_{13}, \alpha_{11}, \alpha_{12}, \beta_{11}$ and others are significant.

[10] Estimates of other parameters are excluded from the text.

[11] Note that the asymmetric effect of volatility $\alpha_{12} < 0$ is not found in the J-REIT market. We found that the estimated ρ_{12}, ρ_{13} and ρ_{23} yield the positive definite of conditional covariance matrix, H_t. Tables 4 to 9 show the positive definite for H_t.

[12] However, these J-REIT estimates support the findings in Redman and Manakyan (1995) and Clayton and Mackinnon (2003) for the specific US-REIT where the housing price is the determinant of the REIT price.

5.2. Parameter Estimates and Dynamic Effects

Our interest on the two shocks (2008 crisis and 2011 earthquake) on the J-REIT leads us to include the dummy variables for September 2008 or March 2011 in Γ_1 shown in Equation (3), and estimate their coefficients and investigate the effects of the earthquake on the causality between the J-REIT price index (for REIT market), TOPIX (for stock market) and J-HP index (for real estate market). Studies by Case *et al*. (2012a, 2012b) and Chang and Chen (2014) showed that the impact of the 2008 crisis on the REIT's market was observed in US as well as other markets. We should then consider the shock of 2008 crisis on the J-REIT market together with the 2011 earthquake. We estimate a VAR model based on Equations (4), (5) and (8), shown as:

$$\Delta Y_t = A_0 + \tilde{\Gamma}_1 \Delta Y_{t-1} + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \left| \Omega_{t-1} \sim N\left(\mathbf{0}, \mathbf{H}_t\right)\right.$$
$$\tilde{\Gamma}_{1,1} \equiv \left(\gamma_{11} + D_{1t}\gamma'_{11} + D_{2t}\gamma''_{11},\ \gamma_{12} + D_{1t}\gamma'_{12} + D_{2t}\gamma''_{12},\ \gamma_{13} + D_{1t}\gamma'_{13} + D_{2t}\gamma''_{13}\right) : \tilde{\Gamma}_{1,1} \text{ is the first row of } \tilde{\Gamma}_1 \quad ,(8)$$
$$D_{1t} = \begin{cases} 0 \\ 1 \ \ if \ \ Sep.2008 \le t < Mar.2011 \end{cases} \quad D_{2t} = \begin{cases} 0 \\ 1 \ \ if \ \ Mar.2011 \le t \end{cases}$$

The parameter estimates are shown in Table 5. We replace $\tilde{\Gamma}_1$ for Γ_1 in Equation (7), where $\tilde{\Gamma}_{1,1}$ is the first row vector and other rows do not include dummies. This formulation means that the parameters

γ_{11}(J-REIT to J-REIT), γ_{12}(TOPIX to J-REIT) and γ_{13}(J-HP to J-REIT)

correspond to the parameters before September 2008, while

$\gamma_{11}+\gamma'_{11}$(J-REIT to J-REIT), $\gamma_{12}+\gamma'_{12}$(TOPIX to J-REIT) and $\gamma_{13}+\gamma'_{13}$ (J-HP to J-REIT)

correspond to the parameters during September 2008 and February 2011 and,

$\gamma_{11}+\gamma''_{11}$(J-REIT to J-REIT), $\gamma_{12}+\gamma''_{12}$((TOPIX to J-REIT)) and $\gamma_{13}+\gamma''_{13}$ (J-HP to J-REIT)

correspond to the parameters during March 2011 to December 2014. All the estimated EGARCH terms and constant correlations, α_{11} and $\beta_{11}, \rho_{12,}$ and ρ_{13} in Equation (4) and (5), are significant.

Table 5 reveals the impacts from the 2008 global financial crisis and the 2011 great earthquake. Prior to 2008, the determinant for the REIT price was J-HP, namely the housing price (significantly positive γ_{13}>0) and not the TOPIX. But during both crises of September 2008 and February 2011, the determinant was only the TOPIX (significantly positive $\gamma_{12}+\gamma'_{12}$(TOPIX to J-REIT) =0.078+0.736>0). However, since the March 2011 crisis, the determinant was only the housing price (significantly positive $\gamma_{13}+\gamma''_{13}$ (J-HP to J-REIT) =2.080+0.352>0), while the impacts on the J-REIT price increased by 0.352 (but insignificant), thereby showing the importance of the housing prices. After the March 2011 crisis, the effects of housing price on the J-REIT price become stronger and at the same time, the housing price index was lower and stagnated as seen in Figure 3(a). With the exception of the 2008 crisis, the determinant of the J-REIT price seemed to be the housing price only.

Table 5 Parameter Estimates with Dummies on September 2008 and March 2011

	γ_{11}	γ_{12}	γ_{13}	γ_{11}'	γ_{12}'	γ_{13}'	γ_{11}''	γ_{12}''	γ_{13}''
REIT	0.251**	0.078	2.080**	-0.633**	0.736**	-1.482**	-0.089**	-0.098**	0.352
	(0.071)	(0.055)	(0.571)	(0.100)	(0.159)	(0.885)	(0.012)	(0.046)	(0.793)
	α_{11}	α_{12}	β_{11}	ρ_{12}	ρ_{13}	ρ_{23}			
	0.462**	0.215**	0.850**	0.626**	0.178**	0.155**			
	(0.121)	(0.069)	(0.073)	(0.052)	(0.070)	(0.066)			

Note: Standard errors are in parenthesis. * and ** are significant at 10% and 5% level, respectively.

Next, we investigate the dynamic effects by comparing the estimates for the pre-2008 period and 2008 crisis, the 2011 earthquake and post-2011 period. We examine if the impacts of these two shocks converge (disappear) or not. Table 6 summarizes the coefficients for each of the J-REIT to J-REIT, TOPIX to J-REIT, and J-HP to J-REIT for the three periods, ignoring the significance of estimated coefficients. The 2008 crisis has strengthened the effect of TOPIX on J-REIT from 0.078 to 0.814, while its effect disappeared (-0.020) after the crisis. On the other hand, the 2011 earthquake has led to a recovery in the effect of J-HP on J-REIT from 0.598 to 2.432, and moreover, the effect on J-REIT was strong in the pre-2008 period (2.080). Thus, one can argue that the housing price determined mainly the REIT price prior to the two shocks. In the 2008 crisis, however, the TOPIX was the main determinant of REIT with a converging effect. After the 2011 earthquake, the J-HP was the main determinant of REIT with a strengthening effect.

Table 6 The Dynamic Effects of 2008 Crisis and 2011 Earthquake

REIT	J-REIT To J-REIT	TOPIX to J-REIT	J-HP to J-REIT
May 2003-Sep. 2008	0.251	0.078	2.080
Sep. 2008-Mar. 2011 (2008 Crisis)	-0.382	0.814	0.598
Mar. 2011-Dec.2014 (2011 Earthquake)	0.162	-0.020	2.432

6. Robustness Checks: Global Effects and Dividend Variables

Figure 4 shows that in the J-REIT market foreigners are the major traders in the decade of 2003-2012. Studies in Ling and Naranjo (2002), Hamelink and Hoesli (2004) and Bond *et al*. (2004) found that international real estate and country-specific factors are important. As such, we incorporate the viewpoints of international trading with the foreign REIT price (e.g. US-REIT). The robustness checks are conducted by including exogenous variables of the US-REIT price index, US-Housing price index and S&P500, X_{t-1}, in Equation (3) of the US global variables and estimate their coefficients in Equation (9) that included the exogenous variables as follows.

$$\Delta Y_t = A_0 + \tilde{\Gamma}_1 \Delta Y_{t-1} + \Phi \Delta X_{t-1} + \varepsilon_t : \ \boldsymbol{\varepsilon}_t \big| \Omega_{\text{t-1}} \sim N\left(\mathbf{0}, \mathbf{H}_t\right) \text{, t = 1, … , T.} \tag{9}$$

$$\tilde{\Gamma}_{1,1} \equiv \left(\gamma_{11} + D_{1t}\gamma'_{11} + D_{2t}\gamma''_{11},\ \gamma_{12} + D_{1t}\gamma'_{12} + D_{2t}\gamma''_{12},\ \gamma_{13} + D_{1t}\gamma'_{13} + D_{2t}\gamma''_{13}\right)$$

$$D_{1,t} = \begin{cases} 1, & \text{if Sep.2008} \le \text{t} \le \text{Feb.2011} \\ 0, & \text{other} \end{cases} \qquad \text{D}_{2,t} = \begin{cases} 1, & \text{if Mar.2011} \le \text{t} \\ 0, & \text{other} \end{cases}$$

$$\Phi = \begin{pmatrix} b_1 & b_2 & b_3 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \qquad \Delta X_{\text{t-1}} = \begin{pmatrix} \text{US-REIT} \\ \text{NYSE} \\ \text{US-HP} \end{pmatrix}$$

The first row (J-REIT) includes the US effects for the US-REIT, S&P500, and US-HP. The results, shown in Table 7, separate the Japanese effects and the US international effects on the J-REIT. The S&P500 effect, b_2= 0.002, and the TOPIX effect, γ_{12} = 0.052, on J-REIT are significant and they sum to 0.054, which is close to the insignificant γ_{12} =0.078 without the S&P500 effect in Table 5. Also, the US-HP effect, b_3= 0.424, and the JP-HP effect, γ_{13} =1.997, on J-REIT are significant and they sum to 2.421, which is close to γ_{13} = 2.080 without the US-HP effect in Table 5. Thus, since the estimates for the Japan effect in Table 5 involve also the estimates of the US effects in Table 7, though the US effects are relatively small when compared to the Japan effects, we conclude that the results in Table 7 are both quantitatively and qualitatively similar to those in Table 5. Namely, the housing price determines mainly the REIT price (γ_{13} =1.997, $\gamma_{13} + \gamma'_{13}$ =1.997-1.328, $\gamma_{13} + \gamma''_{13}$ =1.997+0.126). However, the TOPIX effect on J-REIT is significantly positive (γ_{12} = 0.052). It largely shows up during the 2008 crisis ($\gamma_{12} + \gamma'_{12}$ =0.052+0.767) and disappears ($\gamma_{12} + \gamma''_{12}$ =0.052-0.054) after the 2011 earthquake tsunami. The S&P500 effect on J-REIT is insignificantly positive (b_2 = 0.002). The US-HP effect is only significantly positive on the J-REIT, showing the contagion to J-REIT market. A serious analysis shall include the dummy variable into the effect of the US global variable. These results are reported in Appendix 2, which show similar results reported in Table 7 with no dummy variables.

Table 7 Parameter Estimates of CC-GARCH model with US and Dummy Variable

	γ_{11}	γ_{12}	γ_{13}	γ_{11}'	γ_{12}'	γ_{13}'	γ_{11}''	γ_{12}''	γ_{13}''
REIT	0.222**	0.052*	1.997**	-0.605**	0.767**	-1.328	-0.051**	-0.054	0.126
	(0.081)	(0.031)	(0.545)	(0.201)	(0.222)	(0.932)	(0.004)	(0.073)	(0.888)
	b_1	b_2	b_3	ρ_{12}	ρ_{13}	ρ_{23}			
	-0.021	0.002	0.424*	0.622**	0.175**	0.155*			
	(0.063)	(0.110)	(0.249)	(0.052)	(0.084)	(0.080)			

Note: Standard errors are in parenthesis. * and ** are significant at 10% and 5% level, respectively.

Another robustness check can be conducted by using the dividend yield for all variables in Equation (9) as in Case *et al*. (2012a, 2012b) and Milunovich and Truck (2013). The results are reported in Table 8. By using different variables, the sizes of estimated coefficients are slightly different, while the signs of coefficients are similar and the results are similar to those shown in Table 7. Thus, we conclude that the results in Table 7 are robust.

Table 8. Parameter Estimates of CC-GARCH model with US and Dummy Variable by Total Return indices

	γ_{11}	γ_{12}	γ_{13}	γ_{11}'	γ_{12}'	γ_{13}'	γ_{11}''	γ_{12}''	γ_{13}''
REIT	0.221**	0.016**	1.999**	-0.440**	0.571**	-1.145	-0.068**	-0.007	0.059**
	(0.004)	(0.007)	(0.024)	(0.173)	(0.213)	(0.762)	(0.000)	(0.014)	(0.014)
	b_1	b_2	b_3	ρ_{12}	ρ_{13}	ρ_{23}			
	-0.018**	0.011**	0.462**	0.639**	0.170**	0.152**			
	(0.000)	(0.002)	(0.018)	(0.048)	(0.078)	(0.077)			

Note: Standard errors are in parenthesis. * and ** are significant at 10% and 5% level, respectively.

7. Concluding Remarks

This empirical paper examines how the real estate and the stock price are affecting the J-REIT prices (the so-called hybrid price of both real estate and stock prices) by using an event study that included the impact from the 2008 financial crisis and 2011 earthquake tsunami. In particular, we focus on whether the impacts have imposed a permanent change or have converged. A total of four VAR models are constructed to incorporate different scenarios derived from the data, including the CC-EGARCH term, the incorporation of structural change, the presence of international variables and the use of dividend yield. The empirical study shows convincingly that the real estate price affected the J-REIT price much stronger than the stock price, as opposed to the results of the US-REIT.

In the case of the 2008 crisis, the empirical results show that the effects of stock price on the J-REIT price clearly appeared while the effect of real estate price disappeared temporary. In the case of the 2011 earthquake, the impact of the real estate price on the J-REIT market became larger and seemed to have continued permanently, with no recovery on sight. These results are robust for the presence of the international variables and dividend yield, though the inclusion of these variables changes the size of coefficients. Also, as seen in Table 7, the US-REIT and S&P500 effects on J-REIT are insignificant, but the US-HP effects are significant and positive on the J-REIT. These findings suggest that the main determinant of the J-REIT price in the long-run is the real estate price in Japan as opposed to that in the US. However, the US-REIT related factors (in particular the US-HP) do have contagious effect on the J-REIT market. Therefore, the J-REIT market will not recover if the J-HP and the US-HP do not recover, even though the US-REIT market recovers together with the S&P500 market.

The empirical studies shown in this paper, especially in the event study of the earthquake in Japan, will have further implications in business decisions on investment between Japan's real estate and stock markets, and between Japan's real estate and US's real estate markets. A new measure on the risk and return between these investment markets may have to be constructed.

Appendix 1. Unit Root and Cointegration Analysis

Before estimating the data generating process of VAR model in (1) equivalently of ECM model in (2), we must check the stationarity of our time-series data, and further test whether there are cointegrating relationships among those variables if they are not stationary. Table A1 reports the Augmented Dickey–Fuller (ADF) tests for a unit root. All price index are integrated of order one, i.e., I(1) except for the test with τ_μ for J-Housing, which concludes all variables I(1).

Table A1. ADF Tests for Unit Root

		Lag length		ADF Test statistic δ		
		Level	1st Difference	Level	1st Difference	5% Critical Value
y_{1t} (J-REIT)	τ	1	0	0.583	-9.436**	-1.943
	τ_μ	1	0	-1.318	-9.434**	-2.882
	τ_τ	1	0	-1.243	-9.413**	-3.442
y_{2t} (TOPIX)	τ	1	0	0.637	-8.784**	-1.943
	τ_μ	1	0	-1.709	-8.792**	-2.882
	τ_τ	1	0	-1.857	-8.762**	-3.442
y_{3t} (J-Housing)	τ	9	8	0.252	-2.609**	-1.943
	τ_μ	9	8	-2.917**	-2.600*	-2.882
	τ_τ	9	8	-2.920	-2.605	-3.442

Note: For each time series, we specify the model as

$$\Delta y_t = \boldsymbol{\mu} + \tau \cdot t + \sum_{i=1}^{p-1} \gamma_i \Delta y_{t-i} + \delta y_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim N\left(\mathbf{0},\ \sigma^2\right)$$

The ADF statistic tests the hypothesis $H_0 : \delta = 0$ vs $H_1 : \delta < 0$. Similarly, we carry out ADF tests for the log-difference variables. MacKinnon (1999)'s 5% critical values are shown. The Schwartz Information Criterion (SIC) is used to choose the lag length. * and ** are significant at 10% and 5% level, respectively.

We analyze the price indexes by using the model described in Section 3, in which the three variables for the J-REIT index, TOPIX and J-Housing Prices index (with the difference of logarithm) are denoted by $Y_t = \left(y_{1,t},\ \cdots, y_{3,t}\ \right)'$ and the exogenous variables (with the difference of logarithm) by $\Delta X_{t-1} = \left(\Delta x_{1,t-1},\ \cdots, \Delta x_{3,t-1}\ \right)'$ and Gaussian errors ε_t. It is equivalently in an error correction form is as in (3). We specify the model as:

$$\Delta Y_t = A_0 + \sum_{i=1}^{p-1} \Gamma_i\ \Delta Y_{t\text{-}i}\ + \alpha\beta\ '\ Y_{t\text{-}i} +\ \Phi \Delta X_{t-1} + \varepsilon_t, \qquad \text{(A1)}$$

The lag lengths are determined by the Schwartz Information Criterion (SIC). In Table A2, the minimum value of SIC attains at an optimal lag length of p = 2 out of two to five. We may safely conclude that the data generating process follows the model of (A2) with p = 2.

Based upon this finding, we test the hypothesis; $H_0 : rank(\beta) = r$ against $H_1 : rank(\beta) = 3$ by using Johansen's max-eigen value test.[13] The third column of p = 2 in Table A2 reveals that there is no cointegrating relationship for any countries at the 5% level. For checking the robustness of this result, we carry out the max-eigen value test for the models with lag length of two through five. As shown in Table A2, there is no cointegrating relationship for any lag length at the 5% level. The result of cointegration test is quite robust against the lag length for the model of (A2) or (3). Preliminary analysis of this study justifies the model of equation (3) in Section 3 for subsequent analysis.

Table A2. Cointegration Tests

	Lag	p-1 = 1	p-1 = 2	p-1 = 3	p-1 = 4
	SIC	-24.16***	-23.96	-23.70	-23.50
Max-Eigen Value Statistics	H_0: r = 0 vs H_1: r = 1 (5% Critical Value = 22.30)	18.72	13.56	15.99	16.27
	P-Value	(0.147)	(0.503)	(0.299)	(0.280)
	Resulting rank	0	0	0	0

Note: The symbol "***" in SIC denotes the minimum SIC. * and ** are significant at 10% and 5% level, respectively.Figures in parentheses are p-values (Mackinnon et al.(1999)) .

Appendix 2. The Dummy Variable into the Effect of the US Global Variable.

Strict analysis by checking more robustness may require us to include the dummy variable into the effect of the US global variables, which includes the dummy variables into coefficients of global variables in Equation (9) as follows.

$$\Delta Y_t = A_0 + \tilde{\Gamma}_1 \Delta Y_{t-1} + \Phi \Delta X_{t-1} + \varepsilon_t : \ \boldsymbol{\varepsilon}_t \big| \Omega_{t-1} \sim N(\mathbf{0}, \mathbf{H}_t) \text{ , t = 1, … , T.} \qquad \text{(A2)}$$

$$\tilde{\Gamma}_{1,1} \equiv \left(\gamma_{11} + D_{1t}\gamma'_{11} + D_{2t}\gamma''_{11},\ \gamma_{12} + D_{1t}\gamma'_{12} + D_{2t}\gamma''_{12},\ \gamma_{13} + D_{1t}\gamma'_{13} + D_{2t}\gamma''_{13}\right)$$

$$D_{1,t} = \begin{cases} 1, & \text{if Sep.2008} \le \text{t} \le \text{Feb.2011} \\ 0, & \text{other} \end{cases} \qquad \text{D}_{2,t} = \begin{cases} 1, & \text{if Mar.2011} \le \text{t} \\ 0, & \text{other} \end{cases}$$

$$\Phi = \begin{pmatrix} b_1 + D_{1t}b'_1 + D_{2t}b''_1, & \text{b}_2 + D_{1t}b'_2 + D_{2t}b''_2, & \text{b}_3 + D_{1t}b'_3 + D_{2t}b''_3 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \Delta X_{\text{t-1}} = \begin{pmatrix} \text{US-REIT} \\ \text{NYSE} \\ \text{US-HP} \end{pmatrix}$$

[13] Strictly speaking, neither the ADF test nor Johansen's test is applicable. This is because the CC-EGARCH-ECM (Constant Correlation EGARCH Error Correction Model) does not satisfy the assumption of independent identically distributed normal errors. However, for simplicity, we ignore this issue; see Seo (2007) for details.

Those results are shown in Table A.3, which show the similar results to no dummy variables at the US global coefficients in Table 7.

Table A3. Parameter Estimates of CC-GARCH model with US and Dummy Variable

	γ_{11}	γ_{12}	γ_{13}	γ_{11}'	γ_{12}'	γ_{13}'	γ_{11}''	γ_{12}''	γ_{13}''
REIT	0.384**	0.106**	1.519**	-0.978**	1.265**	-1.401**	-0.259**	-0.169**	0.278**
	(0.006)	(0.007)	(0.045)	(0.010)	(0.024)	(0.040)	(0.009)	(0.008)	(0.108)
	b_1	b_2	b_3	b_1'	b_2'	b_3'	b_1''	b_2''	b_3''
	0.155**	-0.400**	0.394**	-0.419**	0.432**	0.487**	-0.324**	0.659**	0.677**
	(0.002)	(0.008)	(0.091)	(0.006)	(0.006)	(0.063)	(0.017)	(0.010)	(0.128)
	ρ_{12}	ρ_{13}	ρ_{23}						
	0.593**	0.185**	0.158*						
	(0.051)	(0.080)	(0.084)						

Note: Standard errors are in parenthesis. * and ** are significant at 10% and 5% level, respectively.

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