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Are there contagion effects in the REIT market? The case of Brexit

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ABSTRACT

On June 23, 2016 the Brexit event that tremendously surprised and shocked investors around the world was considered the largest black swan with a political earthquake in 2016, and even spread to the international financial market and real estate market. This study uses the heteroscedasticity biases based on correlation coefficients by Forbes and Rigobon and the GJR-GARCH model to examine the contagion effects of the Brexit event on global REITs markets. The data are collected at the daily interval covering the time period from June 23, 2015 to December 30, 2016. Evidence reveals that no REITs markets suffered from Brexit, suggesting no transmission of Brexit across REITs markets, even the neighbouring markets, is found.

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1. Introduction

In recent years, due to the high liquidity of funds in the international market, the financial markets have become more internationalised and liberalised. International financial integration can promote economic development by improving the domestic financial system with positive ramifications for long-run productivity growth (Levine, 2001). However, through internationalisation, a country that undergoes major political, financial, social and economic changes may directly or indirectly affect the stability of financial markets in other countries.

On June 23, 2016, the United Kingdom decided to withdraw from the European Union, known as Brexit, with a vote of 51.9% for yes (Brexit) to 48.1% for no. The political earthquake in the United Kingdom surprised and shocked investors. It was regarded as the 2016 largest black swan in the world, causing panic selling pressure on global financial markets on the black Friday. The global stock market value evaporated more than $2 trillion USD in less than one day with panicking investors. The pound tumbled to a 30-year low level and the euro has decreased below $1.1 USD.

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At the same time, the VIX panic index once rose to 52%, the stock market plummeted like a plague from the Asian market to the European and American markets, The French and German stock markets dropped by more than 6%.

Additionally, the political earthquake also caused heavy damages to the European real estate markets and Real Estate Investment Trust (REITs) markets. The UK and European housing markets were severely impacted. The UK REITs and the European REITs indices dropped by 14.08% and 8.95% respectively. Furthermore, the UK Morningstar data revealed the UK one-year real estate rate of return decreased by 21.92% and the one-year return on land securities also decreased by 15.15% while the FTSE NPRA/NAREIT UK index reduced by 15.63% from June 23 till July 11, 2016. Simultaneously, the September-October 2016 REITs magazine said that, due to the Brexit political incident, the European real estate market faced the influenced feelings for economic and political uncertainty. Analysts also pointed out that the price of the UK REIT stock reduced by 20% and the price of the UK FTSE EPRA/NAREIT REIT index (in Euros) decreased by 20.9%. According to the Global Industry Classification System (GICS) data, the REITs market accounted for 3.5% of the global stock market value, and ranked the 8th largest industry sector in the world. GICS also announced the separate listing of the REITs equity as an industry for demonstrating the growing importance of REITs. As of the end of 2015, the UK REITs equity accounted for around 6% of the global market capitalisation, ranked the fourth in the world, following the United States, Australia, and France.

Undoubtedly, Brexit is the largest black swan in 2016. The black swan is an unpredictable event that is beyond what is normally expected of a situation and has potentially severe consequences. Black swan events are characterised by their extreme rarity, their severe impact, and the widespread insistence they were obvious in hindsight.[1] The contagion effect of this political earthquake is worthwhile analyzing and discussing in the academic world. Previous empirical studies on the contagion effect of international stock returns focus on the financial crisis (the Asian currency crisis of 1997 and the 2007-2008 financial tsunami), terrorist attacks (the 911 terrorist attack in the USA), and natural disasters (the 1995 Hanshin earthquake in Japan and the 921 earthquake in Taiwan, the 2004 tsunami in Indonesia, and the 311 earthquake in Japan). However, no previous studies have focussed on the contagion effect across global REITs markets triggered by a political earthquake like the 2016 Brexit event. This study is, to our knowledge, the first one to conduct research in this area. This study thus aims to employ the heteroscedasticity biases on unconditional correlation coefficients developed by Forbes and Rigobon (2002) and the GJR-GARCH model to examine the contagion effect of the 2016 Brexit event across global REITs markets. Evidence reveals that no REITs markets suffered from Brexit, suggesting no transmission of Brexit across REITs markets, even the neighbouring markets, is found. Our paper suggests that contagion effects were not detected in international REITs markets, including emerging markets and neighbouring markets, during the Brexit Event.

The remainder of this paper is organised as follows. Section 2 defines contagion effects and review related literature, section 3 describes data and methodology; empirical results are provided and discussed in section 4, and, finally, section 5 is conclusion.

2. Contagion definitions and the related literature

2.1. Definitions of contagion

Not all economists established consensus on the definition of contagion. Forbes and Rigobon (2002) define contagion as a significant increase in market co-movement after a shock that occurred in one country. According to this definition, if two markets display a high degree of co-movement during periods of stability, even if the markets continue to be highly correlated following a shock occurred in one market, this may not constitute contagion. The World Bank defines the contagion effect in more detail. It can be broadly divided into three types: broad definition, restrictive definition and very restrictive definition. As described below: First, broad definition: contagion is identified with the general process of shock transmission across countries. This definition is supposed to work during both tranquil and crisis periods, and contagion is associated not only with negative shocks, but also with positive spill-over effects. Second, restrictive definition: contagion involves the propagation of shocks between two countries in excess of what should be expected based on the fundamentals and considering the co-movements triggered by common shocks. If this definition of contagion is adopted, it is necessary to be aware of what constitutes the underlying fundamentals. Otherwise, it is impossible to effectively appraise whether excess co-movements have occurred and whether contagion is displayed. Third, very restrictive definition: contagion should be interpreted as the change in the transmission mechanisms that takes place during a period of turmoil, and it can be inferred based on a significant increase in the cross-market correlation.

Referring Lee and Wu (2009) for making the result of this study more circumspect, we will focus on the first and third definition of contagion, to examine the level of co-movement and the degree of volatility spill-over after June 23, 2016 Brexit political earthquake on the global REITs markets. Meanwhile, we define contagion both as significant increase in REITs market co-movement after a shock occurred in one country and the spill-over effect to other REITs markets more significantly when political earthquake occurs. Therefore, the paper uses two measure methods to examine contagion effect after 2016 Brexit event by referring to related studies (e,g., Engle & Ng, 1993; Fornari & Mele, 1997; Forbes & Rigobon, 2002; Hon et al., 2004; Lee, 2004; Caporale et al., 2005; Corsetti et al., 2005; Lee et al., 2007; Hon et al., 2007; Saleem, 2009; El Hedi Arouri et al., 2010; Lee & Wu, 2009; Lee, 2012; Asongu, 2012; Asongu, 2013; Chiou et al., 2015; Wu et al., 2018). First, the paper utilises heteroscedasticity biases on unconditional correlation coefficients to test cross-market co-movement. Second, we use GJR-GARCH model to examine the spill-over effects.

2.2. Related literature

Schmukler (2004) pointed out that there are three main channels of contagion have been identified in the literature. Through real links which are often tied to trade links. Via financial channels especially when two economies are connected through the international financial system. Lastly, as a result of herding behaviour or panic resulting from asymmetric information, a financial market might transmit shocks

across other markets. As regards method of measuring contagion, current studies offer many methods to measure the propagation of international shocks across countries. Forbes and Rigobon (2002) indicated that four different methodologies have been utilised to measure how shocks are transmitted internationally: cross market correlation coefficients (King & Wadhwani, 1990; Forbes & Rigobon, 2002; Collins & Biekpe, 2003; Lee et al., 2007; Lee & Wu, 2009; Asongu, 2012; Asongu, 2013); ARCH and GARCH models (Hamao et al., 1990; King et al., 1994; Bekaert et al., 2005; Brailsford et al., 2006; Lee & Wu, 2009; Saleem, 2009); cointegration techniques (Longin & Solnik, 1995; Kanas, 1998; Yang & Bessler, 2008); and direct estimation of specific transmission mechanisms (Forbes, 2000; Ang & Bekaert, 2002). To be consistent with the broad definition and the restrictive definition of contagion, the paper shall adopt Forbes and Rigobon (2002) and GJR-GARCH model for the examination of political earthquake.

Forbes and Rigobon (2002) use the heteroscedasticity bias tests for contagion basing on correlation coefficients, and their empirical findings indicated little evidence of contagion between stock markets after the US stock market crash of 1987, the Mexican peso devaluation of 1994, and the Asian crisis of 1997, which they call interdependence. Lee et al. (2007) also used Forbes and Rigobon (2002) method to examine 26 international stock indexes and the exchange rates whether there are any contagion effect occurred after the strong earthquake in the South-East Asia of 2004, this study shows that no an individual country stock market suffered from the contagion effect, but that the foreign exchange markets of some countries (namely India, Philippines and Hong Kong) did suffer from the contagion effect. Lee and Wu (2009) also used the heteroscedasticity biases based on correlation coefficients and the EGARCH model to examine the contagion effects of natural disasters on the financial markets of neighbourhood countries. The study finds that the contagion effect is more significant in the stock market of the Asian Pacific neighbouring countries after the Osaka-Kobe, Japan earthquake on 1995. The result implies that country with stronger economic capacity might cause the spill-over effect to other international markets (particularly emerging markets) more significantly when the natural disaster (earthquake) occurs. Lee (2012) used the heteroscedasticity biases based on correlation coefficients to examine the existence of the contagion effect for the subprime mortgages crises took place in July, 2007 in US, and this study shows that stock markets of some countries (namely Hong Kong, Taiwan, Australia and New Zealand) did suffer from the contagion effect. Hoesli and Reka (2013) test the contagion for three national markets; however, only detect financial contagion between the US and the UK markets in the subprime crisis period. In our study, we look into the seven international REIT markets, to prove whether they are contagious or not.

With respect to REITs markets, Chiou et al. (2015) also employed unconditional correlation coefficients suggested by Forbes and Rigobon (2002) and GJR-GARCH models to test contagion and found that during the global financial tsunami in 2007 most prominent contagion was found for such small REITs markets as Taiwan and Hong Kong. This implies those countries with smaller market and fewer issuances are more vulnerable to international financial distresses. Chang and Cheng (2016) apply the Granger causality test and a vector auto-regression to examine evidence of cross-

asset contagion among REITs, money, stock, bond, and currency markets in the US from 2006 to 2012. The results indicate that contagion exists from medium-term bond markets to equity markets; REITs, money markets and short-term bond markets show little evidence of cross-asset contagion with other markets; and the currency market shows high co-movement and contagion with equity markets. Wu et al. (2018) also use the heteroscedasticity biases on unconditional correlation coefficients by Forbes and Rigobon (2002) and T-GARCH model to examine the contagion effects of the March 11, 2011 Japanese earthquake, tsunami and nuclear crisis on the global REITs markets and their empirical findings reveal that no individual country REITs market suffered from the contagion effect.

As regards Brexit and financial markets, Ramiah et al. (2017) used the event study methodology to investigate the impact of the outcome of the EU referendum (Brexit) on various sectors of the British economy over the period June–July 2016 and found that the banking and travel and leisure sectors were affected negatively. Hohlmeier and Fahrholz (2018) consider the UK's withdrawal from the EU will have far-reaching consequences on the European economy. However, the ultimate consequences of Brexit, especially for financial markets, depend on the final agreement, which is still under negotiation. In addition, with respect to Brexit and stock markets, Schiereck et al. (2016) found that the short-run drop in stock prices to the Brexit announcement was more pronounced than to Lehman's bankruptcy, particularly for EU banks. Breinlich et al. (2018) do not find a correlation between the share of EU immigrants in different industries and stock market return by Brexit referendum and suggest stock market reactions to the Brexit referendum were mainly driven by exchange rate movements and investors' expectations of an economic slowdown. As for the regional stock market, the reaction to the Brexit referendum is inconsistent. Morales and Andreosso-O'Callaghan (2018) found that Brexit does not appear to have an impact on the performance of market returns in the region and the influence of economic policy uncertainty in the Greater China Region appears to be insignificant, except for Hong Kong. However, Škrinjarić (2019) studied the reactions of selected Central and Eastern European and South and Eastern European stock markets to the Brexit vote on 23 June 2016 and indicated mixed results regarding the abnormal cumulative return series, but the volatility series were found to be significantly affected.

3. Data and Research Design

The daily data used in this study are retrieved from the Datastream and consist of the REITs index for United Kingdom, Canada, United States, Germany, French, Japan, Hong Kong, Singapore and Australia. The sample period extends from June 23, 2015 to December 30, 2016. Since the UK's EU referendum on June 23, 2016 caused house prices volatility, the whole period is accordingly partitioned into fourth nearly sub-periods: the pre-12 month, post-1 month, post-3 month and post-6 month period to observe co-movement, asymmetric volatility and contagion effect of REITs (Hon et al., 2004: Lee & Wu, 2009: Chiou et al., 2015). The pre-12 month period covers from June 23, 2015 to June 22, 2016, the post-1 month period starts from June 23, 2016 to July 22, 2016 and the post-3 month period starts from June 23, 2016 to

Table 1. 2015 GDP and REITs market capitalisation.

Region	Country	GDP Million US Dollars	Sample Rank	World Rank	REITs capitalisation Million US dollars	REITs capitalisation Sample Rank
North America	US	17,947,000	1	1	984,600	1
	Canada	1,552,386	6	11	55,600	7
Europe	Germany	3,357,614	3	4	88,700	6
	U.K.	2,849,345	4	5	92,300	4
	France	2,421,560	5	6	98,900	3
Asia	Japan	4,123,258	2	2	90,800	5
	Hong Kong	309,931	8	38	27,300	9
	Singapore	292,734	9	43	52,400	8
Oceania	Australia	1,223,887	7	14	123,300	2

Source: 1.The GDP data from World Bank on 2016. 2. The exports data from Country Report.
3. The REITs data from Datastream.

September 22, 2016, with the post-6 month period begins from June 23, 2016 and ends on December 30, 2016. Returns are calculated by taking the logarithmic difference between daily closing indices.

Table 1 present GDP, and REITs market capitalisation. As Table 1 shows that U.K. is number four in the all sample countries rank of GDP. As regards of REITs capitalisation, U.K. is number four in the all sample countries rank from Table 1. The evidence indicates that U.K. has the great influence to a world economy.

This study uses correlation coefficient to test the co-movement between U.K. and other sample market REITs, and then apply GJR-GARCH model to detect volatility spill-over for the pre- and post-Brexit crisis. First, the adjusted correlation coefficients with heteroscedasticity biases introduced by Forbes and Rigobon (2002) are employed to examine co-movement effect. The formula of the traditional correlation coefficient is Equation (1).

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \tag{1}$$

According to the adjusted correlation coefficients with heteroscedasticity biases innovated by Forbes and Rigobon (2002) is Equation (2).

$$\rho^* = \frac{\rho}{\sqrt{1 + \left(\frac{\sigma_{xx}^h}{\sigma_{xx}^l} - 1\right)\left[1 - (\rho)^2\right]}} \tag{2}$$

Where ρ and ρ^* are conditional correlation coefficient and adjusted unconditional correlation coefficients with heteroscedasticity biases, respectively. σ_{xx}^h is x REITs return variance in high volatility period and σ_{xx}^l is x REITs return variance in low volatility period. Forbes and Rigobon (2002) indicated that the conditional correlation coefficient increases in higher volatility period, but the adjusted unconditional correlation coefficients with heteroscedasticity biases remains constant during lower or higher volatility period.

First, this study computes correlation coefficient ρ_s (ρ_t) between UK and sample market REITs in normal (Brexit Event of 2016) period. After ρ_S and ρ_t is calculated,

we transform them ρ_t^* and ρ_s^* via Equation (2). If ρ_t^* is larger than ρ_s^*, this result shows that the co-movement is more evident after Black Swan (Brexit Event) of 2016. Furthermore, this study test adjusted correlation coefficients with heteroscedasticity biases via Fisher Z coefficient.

To calculate the adjusted correlation coefficient, the turmoil period often used as the high volatility period and the stable period often used as the low volatility period. Borrowing from Lee et al. (2007), the following hypothesis is then tested

$$H_0 : \rho_t^* \leq \rho_s^*$$

$$H_1 : \rho_t^* > \rho_s^*$$

Where, ρ_t^* is the adjusted correlation coefficient during the turmoil period, and ρ_s^* is the adjusted correlation coefficient during the stable period. H_0 is the null hypothesis of no contagion and H_1 is the alternative hypothesis for the existence of contagion. We compare the difference in correlations between stable (ρ_s^*) and crisis (ρ_t^*) periods is then carried-out. Contagion is then measured by the significance of adjusted correlation coefficients in the crisis period versus those of the stability period. If REITs market contagion exists, co-movement during the crisis period would be more obvious than that of the stable period.

We utilise Fisher's Z transformations of correlation coefficient to test for pair-wise cross country significance. Fisher's Z transformations convert standard coefficients to normally distributed Z variables. Before hypothesis testing, therefore, the ρ value must be transformed to a Z_r value. The following hypothesis testing demonstrates:

$$H_0 : \rho_t^* \leq \rho_s^* \Rightarrow H_0 : Z_{r\,t} \leq Z_{rs}$$

$$H_1 : \rho_t^* \leq \rho_s^* \Rightarrow H_0 : Z_{r\,t} \leq Z_{rs}$$

where $Z_{rt} = \frac{1}{2}\ln\left(\frac{1+\rho_t^*}{1-\rho_t^*}\right)$

$$Z_{rs} = \frac{1}{2}\ln\left(\frac{1+\rho_s^*}{1-\rho_s^*}\right)$$

$$Z = \frac{Z_{r_t} - Z_{r_s}}{\sqrt{\frac{1}{n_t - 3} + \frac{1}{n_s - 3}}}$$

where, n_t (n_s) are number of actual observe days during the turmoil (stable) period. The critical values for the Fisher's Z-test at the 1, 5 and 10% levels are 1.28, 1.65 and 1.96, respectively, so any test statistic greater than those critical values indicates contagion (C), while any test statistic less than or equal to those critical values indicates no contagion (N).

The GARCH model developed by Bollerslev (1986) is used to observe the change of conditional variance. Nevertheless, the ordinary GARCH model does not distinguish the differential impact on volatility between good news and bad news. We thus

use Threshold GARCH (GJR-GARCH) model which allows for the asymmetric news impact (Glosten et al., 1993). The GJR-GARCH model is, therefore, given by:

$$R_t = \mu + \phi R_{t+1} + \varepsilon_t \tag{3}$$

$$h_t = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \gamma \varepsilon_{t-1}^2 d_{t-1} \tag{4}$$

where R_t and R_{t-1} are the REITs returns in time t and time t-1, respectively, ε_t denotes a new shock in time t, and $\varepsilon_t \sim N\left(0, \sqrt{h_t}\right)$, d_{t-1} stands for the dummy variable with a value of unity if $\varepsilon_{t-1} < 0$ and zero otherwise.

Equation (3) describes the first order autoregressive process for the stock return with ϕR_{t-1} capturing autocorrelation. Equation (4) shows that the conditional variance responds asymmetrically to negative and positive shocks in the stock price. Specifically, positive return shocks have an impact of α_1, while negative return shocks have an impact of $\alpha + \gamma$. If $\gamma > 0$, it indicates the process of leverage effects in the conditional variance. Furthermore, if $\alpha_1 + \beta_1 < 1$, it shows that the GARCH model is appropriate.

4. Empirical Results

First of all, this study applies correlation coefficient to test the co-movement between U.K. and other sample market REITs for the pre-623 and post-623 Brexit vote. The pre-623 period covers from June 23, 2015 to June 22, 2016. The post-623 period starts from June 23, 2016 to December 30, 2016. The result of adjusted correlation coefficients with heteroscedasticity biases show in Table 2. Compared with pre-12, post-1, post-3 and post-6 month Brexit, the adjusted correlation coefficients are increasing except for Germany, French and Hong Kong. After the test of Fisher Z coefficient shows that all adjusted correlation coefficients are insignificant after 623 Brexit vote except for Germany, implying that most co-movement does not exist.

This study also compares the coefficient γ before and after 623 Brexit vote, and shows the property of asymmetric volatility. If the coefficient γ becomes larger, indicating that a higher asymmetry after 623 Brexit vote and vice versa. Furthermore, a higher asymmetric volatility after 623 Brexit vote shows that REITs is affected by U.K. and volatility spill-over is existence. Tables 3–5 show the result of GJR-GARCH model. The conditional variance shows that the GARCH terms are mostly statistically significant in all markets for pre-12 crisis period and similar to those findings in prior applications to financial data. The asymmetric volatility is captured by $\gamma > 0$ and the asymmetric response of volatility to return shocks holds, i.e., negative return shocks tend to influence future volatility more than positive return shocks do. γ is significantly positive before the Brexit vote for 4 out of 8 markets. It is worth mentioning that the leverage effect found in the German, showing that investors react much more strongly to past negative return shocks is their wealth has shrunk markedly. Moreover, γ is insignificant for most cases after Brexit vote. All $\alpha + \beta$ is less than one in each market for the four sub-periods, exhibiting that GJR-GARCH model is appropriate.

Table 2. Testing co-movement with adjusted correlation coefficients with heteroscedasticity biases.

		Pre-12 month		Post-1 month				Post-3 month				Post-6 month			
Area	Country	ρ_s^*	σ	ρ_t^*	σ	*Z-test*	Correlation	ρ_t^*	σ	*Z-test*	Correlation	ρ_t^*	σ	*Z-test*	Correlation
North America	United States	0.4036	0.0103	0.4567	0.0076	0.2677	+	0.4160	0.0096	0.1062	+	0.4047	0.0102	0.0123	+
	Canada	0.4874	0.0116	0.5584	0.0080	0.4009	+	0.5229	0.0096	0.3390	+	0.5275	0.0094	0.4985	+
Europe	Germany	0.8910	0.0139	0.7500	0.0415	−1.8612**	−	0.8270	0.0247	−1.7666**	−	0.8559	0.0195	−1.3787**	−
	French	0.7539	0.0140	0.6552	0.0246	−0.8110	−	0.7299	0.0162	−0.3801	−	0.7457	0.0147	−0.1746	−
Asia	Japan	0.4577	0.0083	0.4693	0.0078	0.0605	+	0.4995	0.0066	0.3860	+	0.4981	0.0067	0.4844	+
	Hong Kong	0.3091	0.0121	0.2778	0.0153	−0.1406	−	0.2842	0.0145	−0.1947	−	0.2944	0.0134	−0.1496	−
	Singapore	0.3422	0.0116	0.3487	0.0111	0.0301	+	0.3513	0.0110	0.0732	+	0.3554	0.0107	0.1386	+
Oceania	Australia	0.3589	0.0134	0.3762	0.0120	0.0820	+	0.3954	0.0107	0.3022	+	0.3979	0.0105	0.4211	+

Note: $\rho*$ shows unconditional correlation coefficient, and σ shows volatility of REITs. + presents increase and − indicate decrease.
Source: The author's design and calculation results.

Table 3. Maximum likelihood estimates of GJR-GARCH model for pre-12 and post-1 month Brexit.

		pre-12 month					post-1 month				
		ω_0	α_1	γ	β_1	$\alpha_1+\beta_1$	ω_0	α_1	γ	β_1	$\alpha_1+\beta_1$
North America	United States	0.0000*	−0.0008	0.3751**	0.6303**	0.6295	0.0000	−0.2841	0.9935	0.7476**	0.4635
	Canada	0.0001**	0.2258	0.1107	0.2927	0.4585	0.0000	−0.2578*	0.3162	0.8385**	0.5807
Europe	Germany	0.0000	−0.0357	0.3190**	0.7790**	0.7433	0.0000	−0.0814	−0.1362	0.9723**	0.8909
	French	0.0000	−0.0124	0.2173*	0.7606**	0.7482	0.0000	−0.0370	−0.1965	0.9964	0.9594
Asia	Japan	0.0000*	−0.0574*	0.2435**	0.6962**	0.6388	0.0000	0.0142	−0.3251	0.9681	0.9823
	Hong Kong	0.0000	0.0550	0.1714	0.7321**	0.7871	0.0000	−0.0322	0.0588	0.9263	0.9231
	Singapore	0.0001	−0.0064	−0.0572	0.5411	0.5347	0.0000	0.0035	−0.5039	0.9269*	0.9304
Oceania	Australia	0.0001*	−0.1007**	0.1421	0.7122**	0.6115	0.0001	0.0452	−0.2655	0.5838	0.6290

Note: * and ** denote significance at the 5% and 1% levels, respectively.
Source: The author's design and calculation results.

Table 4. Maximum likelihood estimates of GJR-GARCH model for pre-12 and post-3 month Brexit.

		pre-12 month					post-3 month				
		ω_0	α_1	γ	β_1	$\alpha_1+\beta_1$	ω_0	α_1	γ	β_1	$\alpha_1+\beta_1$
North America	United States	0.0000*	−0.0008	0.3751**	0.6303**	0.6295	0.0000**	0.1668	1.0574	0.0855	0.25230
	Canada	0.0001**	0.2258	0.1107	−0.2927	0.4585	0.0001**	−0.0321	−0.1050	0.3103**	0.27820
Europe	Germany	0.0000	−0.0357	0.3190**	0.7790**	0.7433	0.0000*	−0.1086	0.2566	0.6670**	0.55840
	French	0.0000	−0.0124	0.2173*	0.7606**	0.7482	0.0000*	−0.0934	0.1549	0.7419**	0.64850
Asia	Japan	0.0000*	−0.0574*	0.2435**	0.6962**	0.6388	0.0000	0.0642	−0.1034	0.7851	0.84930
	Hong Kong	0.0000	0.0550	0.1714	0.7321**	0.7871	0.0000**	−0.1088**	0.1920**	0.9360**	0.82720
	Singapore	0.0001	−0.0064	−0.0572	0.5411	0.5347	0.0000	0.0709	0.0432	0.6920*	0.76290
Oceania	Australia	0.0001*	−0.1007**	0.1421	0.7122**	0.6115	0.0001	−0.0548	−0.1102	0.5742	0.51940

Note: * and ** denote significance at the 5% and 1% levels, respectively.
Source: The author's design and calculation results.

Table 5. Maximum likelihood estimates of GJR-GARCH model for pre-12 and post-6 month Brexit.

		pre-12 month					post-6 month				
		ω_0	α_1	γ	β_1	$\alpha_1 + \beta_1$	ω_0	α_1	γ	β_1	$\alpha_1 + \beta_1$
North America	United States	0.0000*	−0.0008	0.3751**	0.6303**	0.6295	0.0000**	−0.1465	0.5456**	0.5892**	0.44270
	Canada	0.0001**	0.2258	0.1107	−0.2927	0.4585	0.0000	−0.0518	0.0287	0.7307	0.67890
Europe	Germany	0.0000	−0.0357	0.3190**	0.7790**	0.7433	0.0000**	−0.1299**	0.1802	0.7394**	0.60950
	French	0.0000	−0.0124	0.2173*	0.7606**	0.7482	0.0001**	−0.1049	0.5301*	0.4351**	0.33020
Asia	Japan	0.0000*	−0.0574*	0.2435**	0.6962**	0.6388	0.0000	0.5395	−0.4298	0.3022	0.84170
	Hong Kong	0.0000	0.0550	0.1714	0.7321**	0.7871	0.0000	−0.0406	0.0275	0.9299**	0.88930
	Singapore	0.0001	−0.0064	−0.0572	0.5411	0.5347	0.0000	0.0409	0.2376	0.6480**	0.68890
Oceania	Australia	0.0001*	−0.1007**	0.1421	0.7122**	0.6115	0.0001	0.2094	−0.2932	0.3960	0.60540

Note: * and ** denote significance at the 5% and 1% levels, respectively.
Source: The author's design and calculation results.

Table 6. Testing REITs volatility spill-over with GJR-GARCH model for Brexit.

		Pre-12 month		Post-1 month				Post-3 month				Post-6 month			
		r_t	σ	r_s	σ	Z-test	Asymmetry	r_s	σ	Z-test	Asymmetry	r_s	σ	Z-test	Asymmetry
North America	United States	0.3751**	0.134	0.994	1.181	0.470	+	1.057	0.601	0.928	+	0.5456**	0.156	0.587	+
	Canada	0.111	0.140	0.316	0.208	0.591	+	−0.105	0.223	−0.595	−	0.029	0.090	−0.357	−
Europe	Germany	0.3190**	0.116	−0.136	0.501	−0.737	−	0.257	0.275	−0.159	−	0.180	0.108	−0.620	−
	French	0.2173*	0.099	−0.197	0.852	−0.435	−	0.155	0.103	−0.308	−	0.5301*	0.219	0.983	+
Asia	Japan	0.2435**	0.078	−0.325	0.479	−1.021	−	−0.103	0.396	−0.732	−	−0.430	0.397	−1.417*	−
	Hong Kong	0.171	0.106	0.059	0.247	−0.319	−	0.1920**	0.047	0.135	+	0.028	0.056	−0.888	−
	Singapore	−0.0572	0.125	−0.504	1.204	−0.336	−	0.043	0.204	0.305	+	0.238	0.167	1.010	+
Oceania	Australia	0.142	0.075	−0.265	0.533	−0.670	−	−0.110	0.264	−0.745	−	−0.293	0.199	−1.587**	−

Notes: σ is standard errors. *, ** and *** denote significance at the10%, 5% and 1% levels, respectively. + presents increase and − indicate decrease.
Source: The author's design and calculation results.

Table 7. Summary of co-movement, volatility spill-over and contagion.

		Post-1 month			Post-3 month			Post-6 month		
		Co-movement	Spill-over	Contagion	Co-movement	Spill-over	Contagion	Co-movement	Spill-over	Contagion
North America	United States	+	+	N	+	+	N	+	+	N
	Canada	+	+	N	+	–	N	+	–	N
Europe	Germany	–	–	N	–	–	N	–	–	N
	French	–	–	N	–	–	N	–	+	N
Asia	Japan	+	–	N	+	–	N	+	–	N
	Hong Kong	–	–	N	–	+	N	–	–	N
	Singapore	+	–	N	+	+	N	+	+	N
Oceania	Australia	+	–	N	+	–	N	+	–	N

Notes: + presents increase and – indicate decrease. N shows that contagion effect does not exist. ( ) denote significance.
Source: The author's design and calculation results.

Table 6 shows the t test of γ for the pre- and post- 623 Brexit vote. Compared to pre-12 and post-1 month Brexit vote, γ is decrease except for Canada and United States. γ is decrease except for and Hong Kong, Singapore and United States after the post-3 month Brexit vote. γ is decrease except for France, Singapore and United States after the post-6 month Brexit vote. In addition, γ is increasing significantly only for United States and French after the post-6 month Brexit vote. However, the Z test of γ for the pre- and post- 623 Brexit vote show that the significantly asymmetric volatility is decrease between pre- and post-Brexit for Japan and Australia, showing that the volatility spill-over effect does exist.

Finally, Table 7 summarises co-movement, volatility spill-over, and contagion. The contagion effect is defined in this study if co-movement and volatility spill-over are simultaneously detected. The results reveal that co-movement and volatility spill-over are all insignificant. Therefore, the contagion effect failed to exist after the Brexit vote. This empirical result is consistent with findings from the REITs market after the 311 Japan earthquake, tsunami, and nuclear crisis of Wu et al. (2018). However, according to the prior study findings, during Brexit event, the financial markets were characterised by large drops in asset prices, increases in market volatility, particularly for EU banks (Ramiah et al., 2017; Schiereck et al., 2016; Hohlmeier & Fahrholz, 2018). Thus, it can be seen that the REITs market operation has more regional characteristics.

5. Conclusions

This study examines whether the 2016 Black Swan (Brexit Event) influenced the stability of the correlation structure in international REITs markets. Using the daily data covering the period from June 23, 2015 to December 30, 2016 retrieved from Datastream, this study empirically tests whether any contagion effects had occurred six months after the 623 Brexit vote in international REITs markets. The methods utilised in this paper are unadjusted and adjusted correlation coefficients and GJR-GARCH models.

Evidence indicates that only the German REITs market experienced significantly stronger correlations with the U.K. REITs market six months down the road.

However, there is more uncertainty in the REITs market, there are less statistically significant positive shocks after the Brexit vote in the United States, Canada, Japan, Singapore, and Australia, which they call interdependence. Our contribution can be summarised as the followings. First, the heteroscedasticity biases on unconditional correlation coefficients and the GJR-GARCH model allow us to examine the contagion effect of the 2016 Brexit event across global REITs markets. Second, the results reveal that no REITs markets suffered from Brexit, suggesting no transmission of Brexit across REITs markets, even the neighbouring markets, is found. Our further research would to improve model and model application, moreover, to explore whether REITs in various countries are defensive to show characteristic of REITs when Brexit occurs. The empirical findings in this research have important managerial implication for academic researchers, policymakers, and institutional investors on the REITs markets. Our results suggest that contagion effects were not detected in international REITs markets, including emerging markets and neighbouring markets, during the Black Swan (Brexit Event) and other political earthquake crisis events. Even though political earthquake crisis events have left international REITs markets unaffected, we cannot neglect the influence which the Black Swan (Brexit Event) could have on the economy because of free mobility of global capital through international trade and investment.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Note

1. https://www.investopedia.com/terms/b/blackswan.asp

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