Received 15 January 2018
Revised 30 January 2018

# A dynamic model for housing price spillovers with an evidence from the US and the UK markets

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## Abstract

**Purpose** – The purpose of this paper is to introduce an empirical model for house price spillovers between real estate markets. The model is presented by using data from the US-UK and London-New York housing markets over a period of 1975Q1-2016Q1 by employing both static and dynamic methodologies.

**Design/methodology/approach** – The research analyzes long-run static and dynamic spillover elasticity coefficients by employing three methods, namely, autoregressive distributed lag, the fully modified ordinary least square and dynamic ordinary least squares estimator under a Kalman filter approach. The empirical method also investigates dynamic correlation between the house prices by employing the dynamic control correlation method.

**Findings** – The paper shows how a dynamic spillover pricing analysis can be applied between real estate markets. On the empirical side, the results show that country-level causality in housing prices is running from the USA to UK, whereas city-level causality is running from London to New York. The model outcomes suggest that real estate portfolios involving US and UK assets require a dynamic risk management approach.

**Research limitations/implications** – One of the findings is that the dynamic conditional correlation between the US and the UK housing prices is broken during the crisis period. The paper does not discuss the reasons for that break, which requires further empirical tests by applying Markov switching regime shifts. The timing of the causality between the house prices is not empirically tested. It can be examined empirically by applying methods such as wavelets.

**Practical implications** – The authors observed a unidirectional causality from London to New York house prices, which is opposite to the aggregate country-level causality direction. This supports London's specific power in the real estate markets. London has a leading role in the global urban economies residential housing markets and the behavior of its housing prices has a statistically significant causality impact on the house prices of New York City.

**Social implications** – The house price co-integration observed in this research at both country and city levels should be interpreted as a continuity of real estate and financial integration in practice.

**Originality/value** – The paper is the first research which applies a dynamic spillover analysis to examine the causality between housing prices in real estate markets. It also provides a long-term empirical evidence for a dynamic causal relationship for the global housing markets.

**Keywords** Dynamic correlation analysis, House price spillover, The UK housing market, The US housing market

**Paper type** Research paper

**JEL Classification —** R31, R32, C58



The paper is an academic study and does not reflect the institutions that the authors work for.

Journal of Capital Markets Studies
Vol. 2 No. 1, 2018
pp. 70-81
Emerald Publishing Limited
2514-4774
DOI 10.1108/JCMS-01-2018-0002

## 1. Introduction

Changing investment preferences of individuals, companies and institutional investors makes real estate investment increasingly global. Asset managers may optimize their return globally through REITs and securitized real estate investments or directly investing in commercial/residential estates in different countries. High net worth individuals (HNWI), managing majority of the world financial/real assets, also have such opportunities. It is not a surprise that a sovereign wealth fund invests in The Empire State Building in New York, office markets of London are also dominated by foreigners or HNWIs inflate residential prices in a global financial center. However, investment patterns may change depending on the characteristics of the relevant real estate sub-markets, and this global trend is specifically noteworthy in USA/New York and UK/London due to socio-cultural, economic and political reasons. Close economic and political relationships between both sides of the Atlantic, specifically after the Second World War, have made their financial markets increasingly integrated. However, risks caused by globalization and internationalization of financial and real estate markets are typically observed in several financial crises such as the Asian financial crisis (1997) and the recent global financial crisis. This integrated trend has long raised questions on the inherent risks of globalization of real estate markets.

In this study, we analyze aggregate- and city-level house price spillovers between USA-UK and New York-London housing markets over the period of 1975Q1-2016Q1. The study employs Ng and Perron (2001) test to investigate the stationarity of the variables. After defining dependent and independent variables through Toda and Yamamoto (1995) causality test, we explore the spillover relationship between the variables by employing both static and dynamic models. For the static analysis, we first check the co-integration between the variables utilizing bounds test analysis proposed by Pesaran *et al.* (2001). After defining country- and city-level co-integration, we employ an ARDL model to investigate the long-term static spillover. FMOLS[1] and DOLS[2] models are also used to check for robustness. Dynamic house price spillover is investigated using Kalman filter and dynamic conditional correlation-GARCH (DCC-GARCH) models.

The study provides contribution to the international real estate investment literature in two ways. First, this is the first study to analyze house price spillovers between USA-UK and New York-London for over 40 years since 1975. Long observation period provides an important opportunity to understand both historical trends and the current picture of the linkages between these leading countries and cities from the spillover perspective. Second, on the empirical side, we found a unidirectional spillover running from US to UK house prices at the country level. However, when we investigate the spillover relationship at city level, we found a unidirectional relationship running from London to New York.

In the next section, we review the literature. Section 3 involves research strategy with the results. The paper ends with a fact sheet summary and a conclusion.

## 2. Literature review

The empirical literature reveals that the end demand in a real estate market is dependent on local factors rather than global factors (Lekander, 2015), and the global real estate market has been growing with its own dynamics. The evidence of the benefits of international real estate investment is convincing (Eichholtz and Kok, 2007) and mostly suggests return enhancement through diversification benefits[3]. For example, Conover *et al.* (2002) empirically showed that by having a significant weight in efficient international portfolios, foreign property has a lower correlation with US stocks than foreign ones. Hoesli *et al.* (2004) found that real estate is an effective portfolio diversifier and optimal allocation to real estate is 15-25 percent. In their studies, Glascock and Kelly (2007) analyzed real estate investment diversification across 21 countries with a data set from January 1990 to July 2005, and found that property type effects are smaller than country effects. Liow and Adair (2009) provided evidence that by using Asian real estate for diversification purposes, the portfolio risk and return profile may improve.

However, growingly globalized and internationally integrated real estate markets may result co-movements in risk and return. From the risk perspective, spillover and contagion risks[4] are analyzed in the literature. But, the studies mostly focused on REIT shares, securitized property markets and inter-country/regional analysis rather than housing markets and cities across countries. Yunus (2009) found evidence that property portfolios from Australia, Hong Kong, Japan, the UK and the USA were tied together in the securitized property markets during January 1990 and August 2007. By employing wavelet analysis for the USA, the UK, Japan, Australia, Hong Kong and Singapore, Zhou (2010) pointed out the fact that not only the co-movement but also its frequency is important in international portfolios. By utilizing the case-resampling bootstrap technique, Hatemi and Roca (2011) found that the relationship of the US market with Australia, Japan and the UK markets after global financial crisis cannot be characterized as the contagion effect. By using a multivariate regime-dependent asymmetric dynamic covariance methodology, Liow *et al.* (2011) found significant mean-volatility linkages among the five major securitized real estate markets under different volatility regimes. From this perspective, Liow and Newell (2012) found that Mainland China, Hong Kong, Taiwan and USA were integrated over 1995-2009 because of their close economic relations and geographical positions. They also suggest that it would be expected that unsecuritized real estate and real estate securities show different behaviors in their volatility interdependence and correlation relationships.

By using asymmetric *t*-BEKK (Baba-Engle-Kraft-Kroner) specification of their covariance matrix and a time-varying copula framework, Hoesli and Reka (2013) analyzed the time-varying behavior between local and global securitized real estate markets, and also between securitized real estate and common stock markets. The authors found evidence of the market contagion between the US and the UK markets after the 2008 crisis. What is more, the findings indicate that we observe a higher level of spillover effects in the US markets from local and global perspectives. Liow and Ye (2014) found a significant volatility shifts in the times of crises in international public property markets. Jones and Richardson (2014) indicated that despite differences in the global financial crisis-related downturns in countries, common outputs are observed, including a decrease in material, in residential construction and property ownership.

This paper provides a contribution to real estate finance and portfolio management from both methodological and empirical perspectives. Taking the interactions between the US and the UK financial markets into account, the literature involves studies on defining co-movement, contagion and spillover effects in stock and other financial markets between the USA and UK (i.e. Finta *et al.*, 2015). However, there is a lack of empirical research on the house price spillovers between the US-UK and London-New York housing markets based on a dynamic model with a long-period data set. In the next section, we examine the spillover analysis between the US and the UK markets at aggregate and the city level, namely, between New York City and London. Any statistically significant result for spillover impacts between these housing markets based on a dynamic model by employing a long-term data will close the gap in the literature.

## 3. Research strategy and results

In the empirical research, we employ quarterly housing prices for the USA and the UK and New York City and London from 1975Q1 to 2016Q1. All four variables are used in logarithmic form in order to obtain elasticity coefficients.

We use R statistical computing software to run the (DCC-GARCH model. Kalman filtering process is achieved by using Gauss Mathematical and Statistical System 5.0. The other empirical tests are conducted in EViews 9.5 for Windows. The data and codes are available upon request.

*Stationarity check*

In the empirical analysis, we first investigate the stationarity level of the variables by using Ng and Perron (2001) test. Ng and Perron (2001) test results are shown in Table I, where LHP_US, LHP_UK, LHP_NY and LHP_LON denote logarithm of the USA, the UK, New York City and London house price indexes, respectively.

The null hypothesis of $Ma_{ze}$ and $MZ_t$ is tested using unit root test and the null hypothesis of MSB and MPT is tested assuming variables are stationary. According to Table I, all house price index variables are found as I(1).

*Causality analysis*

After the stationarity investigation, we used the Toda and Yamamoto (1995) causality test in order to find causality direction between the variables to define dependent and independent variables. For Toda and Yamamoto approach, we should know the maximum order of integration of the investigated variables. Ng-Perron test shows that maximum order of integration is 1. Then, we estimate VAR($k$) model in levels and extended VAR($k$) model with maximum order of integration number (dmax), and we finally estimate augmented VAR (k+dmax) model. This approach allows us to avoid the information loss due to differencing. After we estimate VAR (k+dmax) model, we make Wald test for first $k$ variables. Toda and Yamamoto (1995) causality results are indicated in Table II.

| | Ng-Perron test results | | | |
|---|---|---|---|---|
| | $MZ_a$ | $MZ_t$ | MSB | MPT |
| LHP_US | −10.960 | −2.234 | 0.203 | 8.857 |
| ΔLHP_US | −45.053 | −4.728 | 0.104 | 0.590 |
| LHP_UK | −4.511 | −1.375 | 0.304 | 19.262 |
| ΔLHP_UK | −48.336 | −4.902 | 0.101 | 0.541 |
| LHP_NY | −1.821 | −0.750 | 0.411 | 36.409 |
| ΔLHP_NY | −60.749 | −5.503 | 0.090 | 0.421 |
| LHP_LON | −5.007 | −1.553 | 0.310 | 18.062 |
| ΔLHP_LON | −77.475 | −6.211 | 0.080 | 0.342 |

**Notes:** –Maze, MZt, MSB, MPT critical values respectively; %1 significance level −23.80, −3.42, 0.14 and 4.03% 5 significance level −17.30, −2.91, 0.17 and 5.48 for HP_US, HP_UK, HP_NY and HP_LON variables; – Maze, MZt, MSB, MPT critical values respectively; %1 significance level −13.80, −2.58, 0.17 and 1.78%5 significance level −8.10, −1.98, 0.23 and 3.17 for ΔHP_US, ΔHP_UK, ΔHP_NY and ΔHP_LON variable

**Table I.**
Unit root test results

| From | To | Test Statistics | Prob value | Results |
|---|---|---|---|---|
| LHP_US | LHP_UK | 2.694 | 0.033 | Causality |
| LHP_UK | LHP_US | 1.263 | 0.286 | No causality |
| LHP_NY | LHP_LON | 1.085 | 0.340 | No causality |
| LHP_LON | LHP_NY | 4.688 | 0.010 | Causality |

**Table II.**
Toda and Yamamoto (1995) test results

According to Toda and Yamamoto (1995) test results, we found a unidirectional causality running form the US house price to the UK house price at the country level. However, when we investigate the causality relationship at the city level, we found a unidirectional causality running from London to New York City.

*Static analysis*

After we investigate the causality relationship and define dependent and independent variables, we first check the co-integration relationship between the variables by using the bound test model. At the country-level analysis, causality is found from the USA to the UK; however, at city-level analysis, causality is found from London to New York City. So, in the first model, UK house price is chosen as dependent and US house price is chosen as an independent variable. In the second model, New York house price is chosen as dependent and London house price is chosen as an independent variable.

For the bound test approach, we estimated the unrestricted error correction model (UECM). The UECM model for our study is presented in the following equations for both country and city levels, respectively:

$$\Delta LHP\_UK_t = \alpha_1 + \sum_{i=1}^{m} \alpha_{2,i} \Delta LHP\_UK_{t-i} + \sum_{i=0}^{m} \alpha_{3,i} \Delta LHP\_US_{t-i} + \alpha_4 LHP\_UK_{t-1} + \alpha_5 LHP\_US_{t-1} + \mu_t \quad (1)$$

$$\Delta LHP\_NY_t = \alpha_1 + \sum_{i=1}^{m} \alpha_{2,i} \Delta LHP\_NY_{t-i} + \sum_{i=0}^{m} \alpha_{3,i} \Delta LHP\_LON_{t-i} + \alpha_4 LHP\_NY_{t-1} + \alpha_5 LHP\_LON_{t-1} + \mu_t \quad (2)$$

When we estimate Equations (1) and (2), we test the null hypothesis of $H_0 = \mathrm{a}4 = \mathrm{a}5 = 0$. For decision procedure, we compare the calculated $F$-statistics with Pesaran *et al.'s* (2001) table critical values. If the calculated $F$-statistics is lower (higher) than the bottom (upper) bound, it shows no co-integration (co-integration) between the variables (Narayan, 2004). If the estimated $F$-statistics is between upper and lower bounds, we could not make any exact opinion. Table III presents the co-integration results.

According to Table III, if $F$-statistics are greater than the upper bound, then we reject the null hypothesis for both country-level and city-level models. As a result, we found a long-run co-integration relationship between US and UK house prices and London and New York house prices. After we found the long-run co-integration relationship, we analyzed a long-run static spillover relationship between the house prices variables by using

| $K$ | $F$-statistics | Critical values at 5% significance level | |
|---|---|---|---|
| | | Bottom bound | Upper bound |
| *Country-level analysis (Equation (1))* | | | |
| 1 | 5.99 | 4.94 | 5.73 |
| *City-level analysis (Equation (2))* | | | |
| 1 | 5.96 | 4.94 | 5.73 |

**Notes:** $k$ shows independent variables for Equation (1). Critical values are obtained from Table C1. iii from the research work of Pesaran *et al.* (2001, p. 300)

**Table III.**
Bound test results

the ARDL model. ARDL model representation of our study is presented in the following equations:

$$LHP\_UK_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} LHP\_UK_{t-i} + \sum_{i=0}^{n} \alpha_{2i} LHP\_US_{t-i} + + \mu_t \quad (3)$$

$$LHP\_NY = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} LHP\_NY_{t-i} + \sum_{i=0}^{n} \alpha_{2i} LHP\_LON_{t-i} + + \mu_t \quad (4)$$

For country- and city-level analysis in Equations (3) and (4), respectively, ARDL (4,0) model is selected employing AIC. As a robustness check, we estimate the FMOLS and the DOLS models. The estimated long-term spillover coefficients using ARDL, FMOLS and DOLS models are shown in Table IV for both country and city levels[5].

As can be seen from Table IV, FMOLS and DOLS model results are consistent with the ARDL model results. According to static model results, for country-level analysis, we found that 1 percent increase in the US house price causes 1.56-1.63 percent increase in the UK house price. For the city-level analysis, 1 percent increase in London house price causes 0.60-0.67 percent increase in New York house price.

*Dynamic analysis*

After investigating the static spillover relationship between US-UK and London-New York house prices, we investigate the same relationship dynamically for both regressions- and correlations-based analysis. For correlation-based analysis, we used the DCC-GARCH methodology to detect the time-varying correlation between US-UK and London-New York house prices, in order to analyze spillover. By using the DCC-GARCH methodology, we analyze the dynamic relationship and the behavior of correlations during certain time periods.

DCC-GARCH, which was first introduced by Engle (2002) to investigate the dynamic conditional correlation between two variables, is based on Bollerslev (1990) constant conditional correlation estimator. The most important superiority of DCC-GARCH model is that it can capture possible changes in conditional correlations over time. Therefore, the time-varying DCC-GARCH models allow us an opportunity to analyze the dynamic relationship between two variables. Moreover, DCC-GARCH estimates standardized residuals correlation coefficients and directly takes heteroscedasticity into consideration (Chiang *et al.*, 2007). Furthermore, the DCC-GARCH estimators are often more robust than the GARCH estimators (Engle, 2002).

Figures 1 and 2 denote the dynamic conditional correlation between the US-UK house prices and London-New York house prices, respectively. Both figures indicate that the dynamic correlation between the US-UK and London-New York shows a sharp decline

| | | | |
|---|---|---|---|
| *Country-level Analysis (Equation (3))* | | | |
| Variable/model | ARDL (4,0) Model | FMOLS | DOLS |
| LHP_US | 1.560 | 1.628 | 1.623 |
| C | −2.465 | −2.911 | −2.884 |
| *City-level analysis (Equation (4))* | | | |
| Variable/model | ARDL (4,0) Model | FMOLS | DOLS |
| LHP_LON | 0.602 | 0.669 | 0.668 |
| C | 2.330 | 1.812 | 1.830 |

**Table IV.** Estimated long-term spillover coefficients

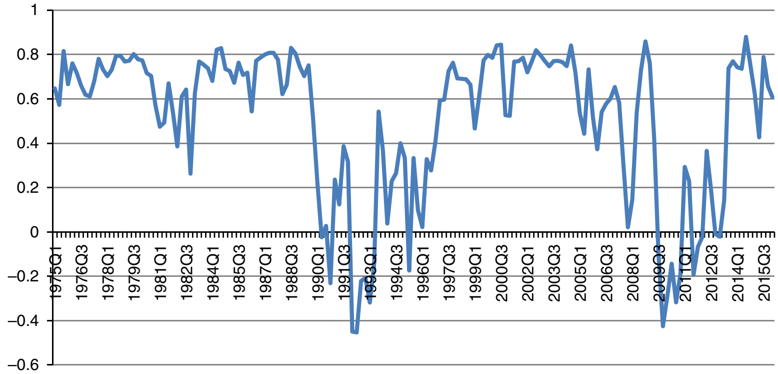



**Figure 1.**
Dynamic conditional correlation between US and UK house prices

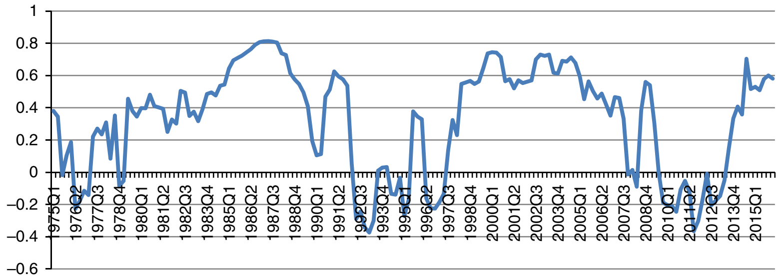



**Figure 2.**
Dynamic conditional correlation between London and New York City house prices

during global financial crises and mid-1990s. This result may indicate that the house pricing relationship is broken under the crisis. Thus, the correlation observed between these markets has conditional characteristics, i.e. it disappears under the stress periods. This requires a more nuanced analysis.

After the dynamic correlation analysis, we employ dynamic regression analysis by employing Kalman filter model. The Kalman filter model allows us to investigate the dynamic spillover relationship both for country-level and city-level variables. Our dynamic Kalman filter approach is based on Harvey's methodology (Harvey, 1989).

The Kalman filter model for our study is shown in the following equations:

$$LHP\_UK_t = a_0 + a_{1,t} LHP\_US_t + \varepsilon_t \tag{5}$$

$$a_{i,t} = a_{i,t-1} + v_{i,t} \tag{6}$$

$$LHP\_NY_t = a_0 + a_{1,t} LHP\_LON_t + \varepsilon_t \tag{7}$$

$$a_{i,t} = a_{i,t-1} + v_{i,t} \tag{8}$$

The time-varying regression parameter estimates for the US-UK house price spillover coefficients are shown in Figure 3 and London-New York house price spillover coefficients are shown in Figure 4.

As the results display clearly, the dynamic regression coefficients are consistent with the static model results. However, the spillover impact dramatically decreases in the crisis period.

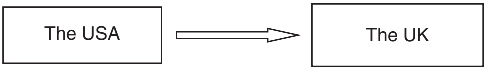
## 4. Research summary and conclusion

The empirical tests based on different methodologies produce the results as shown below.

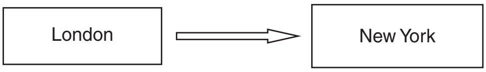
*Causality analysis*

We found a unidirectional causality running from the US house price to the UK house price at the country level. However, when we investigate the causality relationship at city level, we found a unidirectional causality running from London to New York.

Unidirectional causality in house prices




Unidirectional causality in house prices




*Results of static model analysis*

According to static model results, for the country-level analysis, 1 percent increase in the US house price has 1.56-1.63 percent increase in the UK house price. For the city-level analysis,

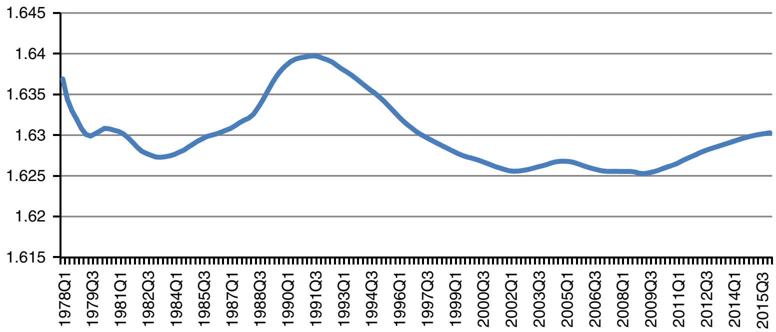



**Figure 3.**
Time-varying parameter estimates for US-UK house price spillover

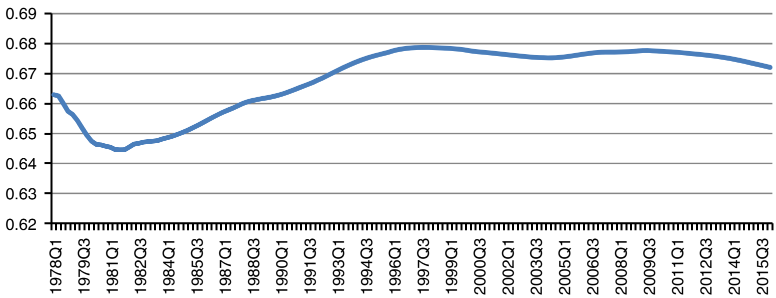
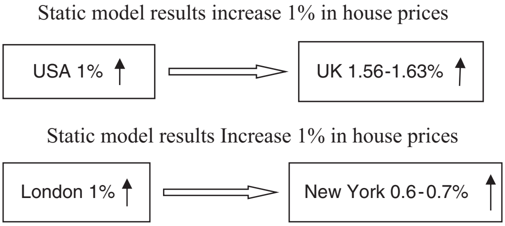



**Figure 4.**
Time-varying parameter estimates for London-New York house price spillover

1 percent increase in London house price results in 0.60-0.67 percent increase in New York City house price.




*Dynamic model analysis*

We observe a dynamic conditional correlation between the US-UK and London-New York house prices. There are highly sensitive dynamic correlations, which decline sharply during the crisis period.

Unidirectional causality in house prices from the US to the UK markets might be seen as a reflection of the consequence of general dominance of the US financial markets over the international markets. However, our findings imply that the dynamic spillover relationship is broken under crisis. The reason for this might be specific for the selected countries. For example, Fernandez *et al.* (2016) discussed transnational wealth elites buying residential properties in New York City and London as an investment rather than as a primary residence.

New York City and London real estates are perceived as a highly liquid investment. Together with the safe haven and socio-cultural characteristics of both cities and the way the real estate market and its professionals is organized, the global city residential market may seem as a "safe deposit box." We observed a unidirectional causality from London to New York house prices, which is opposite to the aggregate country-level causality direction. This might be explained by London's specific power in the real estate markets. London has a leading role in the global urban economies residential housing markets and the behavior of its housing prices has a statistically significant causality impact on the house prices of New York City. Finally, the house price co-integration observed in this research at both country and city levels should be interpreted as a continuity of real estate and financial integration in practice.

The future research on this issue may focus on several questions. The first focus might be on the question that why and how the dynamic conditional correlation between the US and the UK housing prices breaks during crisis periods. Markov switching regime shifts might be selected to investigate the answer of this question empirically. Second, the timing of the causality between the house prices can be examined empirically. Methodologies based on wavelets might be applied to discuss the timing impact of the causality on the housing prices in the markets.

**Notes**

1. FMOLS model is more robust for serial correlation, endogeneity and multicollinearity problems and superior than simple OLS model (Stock and Watson, 1993).
2. In the DOLS model, right-hand side differenced lead and lag variables are used in order to control endogeneity and serial correlation problems (Stock and Watson, 1993).

3. As an example of the opposite view, Bardhan *et al.* (2007) found a negative correlation between a country's risk-adjusted real estate security excess and its openness.
4. Perry and Lederman (1998) differentiated contagion from spillover effects. In this respect, authors argued that while contagion results in financial vulnerability and crisis, spillover effects do not necessarily result in crisis. Dornbusch *et al.* (2000) discussed that contagion indicates the diffusion of market disturbances between countries, a process observed through co-movements in financial indicators/markets. In this respect, spillover is defined as one of the causes of contagion arising from interdependence among market economies. These forms of co-movements would not normally cause contagion, but if they happen during crises period and have a negative effect, then they may be thought as contagion.
5. According to diagnostic checks for ARDL models in Equations (3) and (4), there are not any serial correlations, misspecification and heteroscedasticity problems for our models. The results could be taken from authors upon interest.

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