Asymmetries in Volatility and Spillovers and Market Development: A Comparative Study of Advanced, Emerging and Frontier Stock Markets

Mohammad Khaleq Newaz[1], Jin Suk Park[2]

School of Economics, Finance and Accounting, Coventry University, Priory Street, Coventry, CV1 5FB, UK

E-mail: mohammad.newaz@coventry.ac.uk[1]; jin.park@coventry.ac.uk[2]

Abstract

This paper studies the asymmetric volatility and spillovers and their relationship with market development in 74 advanced, emerging and frontier stock markets between January 2000 and July 2016. The EGARCH, the asymmetric CGARCH, cross-variance shares and the asymmetric full-BEKK models are employed. They investigate how strongly the asymmetric volatility and the asymmetric spillovers from the US market exist across three groups of the markets. A separate regression model examines the relationship between the degree of asymmetries and the level of market development. The results show market development should be considered in the investigation of asymmetries and spillovers. The asymmetric volatility is discovered in 99%, 87% and 64% of the advanced, the emerging and the frontier markets while the spillovers account for 22%, 10% and 3% of forecast errors in those markets, respectively. The asymmetry in the shock spillovers is observed more strongly in the advanced and the emerging markets than the frontier markets. Market development as trading volume per GDP is positively related to both asymmetries. The post-crisis data contains a spillover jump but supports the robustness of the findings.

Key words: asymmetric volatility, leverage effect, spillovers

EFM classification code: 630

1. Introduction

The relationship between stock return shocks and the responses of future volatility has often been documented as asymmetric (Engle & Ng 1993) meaning that a negative shock to stock returns increases volatility to a greater extent than the increase by a positive shock of the same magnitude (Wang et al. 2015; Badshah et al. 2016). This 'asymmetric volatility' is also tightly connected to the 'leverage effect' which commonly refers to a negative relationship between returns and volatility such as higher/lower volatility in bear/bull markets (Kristoufek 2014). Black (1976) and Christie (1982) introduced the leverage effect as a cause of asymmetric volatility since a negative return shock decreases the market value of a company, increases its leverage, raises the uncertainty of the firm value and thus the volatility of returns. On the other hand, the volatility feedback hypothesis (Pindyck 1984; French et al. 1987; Campbell & Hentschel 1992) also explains the negative relationship between stock returns and volatility. They argue that an increase in expected volatility raises the required return on stocks and thus decreases current stock prices. Negative market or nation-wide shocks such as proposed changes in tax policy, central bank interest rate, political unrest, unstable economic situations, natural disasters, or terrorist attack could destabilise the stock markets more strongly than positive shocks. However, neither hypothesis completely explains the asymmetry (Badshah et al. 2016).

The 'spillovers' or the cross-market news effects are also important topics in the stock market literature. Generally, a shock to one stock market and its volatility can be transferred to other markets and affect the volatility in the recipient markets. The former can be defined as 'shock spillovers' and the latter as 'volatility spillovers' (Baruník et al. 2016). These spillovers across markets are expected to be larger when the markets are highly interconnected. Also, just like asymmetric volatility, asymmetry may exist in spillovers (Li & Giles 2015; Baruník et al. 2016). That is, a negative shock to one market could affect the volatility of the other markets differently from a positive shock. Since volatility provides informative measures relevant for risk valuation, derivative pricing and portfolio diversification strategies (Garcia & Tsafack 2011), the asymmetries in volatility and spillovers deserve more investigation across different markets.

There is an abundance of studies that examine the presence of asymmetric volatility in the context of advanced or developed (Smith 2016; Badshah et al. 2016; Chkili et al. 2012) and large emerging markets such as BRIC (Christensen et al. 2015a; Wang et al. 2015; Long et al. 2014; Hou 2013). Spillovers and their asymmetry are also investigated in various markets including some emerging markets (Abou-Zaid 2011; Asai & Brugal 2013; Baumöhl & Lyócsa 2014; Beirne et al. 2013); however, comprehensive empirical studies on asymmetric volatility and spillovers covering a wide range of the advanced, the emerging and the frontier markets[1] are almost non-existent.

Particularly, the frontier markets are not commonly examined even though they are responsible for much of the global output growth during the post financial crisis period (United Nations 2014) and experienced a seven-fold increase in portfolio investment between 2008 and 2014 (Abidi et al. 2016) reflecting the improved governance, accountability and regulatory system of the frontier markets since the mid-2000s. This is somewhat of a contrast to many studies of the international diversification literature (Kiviaho et al. 2014; Bley & Saad 2012; Abdalla 2012; Samarakoon 2011; Berger et al. 2011a; Baumöhl & Lyócsa 2014), which focus on the low correlation between the frontier and the global stock markets.

Univariate GARCH-family models are the most commonly employed models in the investigation of stock return volatility and its asymmetric effects in individual countries. For example, Smith (2016; 2015) reports the presence of leverage effects in S&P 500 index returns

[1] This study follows the classification of MSCI (Morgan Stanley Capital International) market indices. MSCI emerging markets index is available for 25 countries including the powerful BRICS nations. MSCI frontier markets' index is available for 32 countries. Frontier markets are smaller, less accessible, yet still investable countries in the developing world (Berger et al. 2011b).

by using the EGARCH model. Friedmann and Sanddorf-Köhle (2002) and Chen et al. (2001) report that bad news increases volatility more than good news in A-share and composite indices, whereas good news increases volatility more than bad news in B-share indices by estimating both the GJR and the EGARCH model. Zhang and Li (2008) investigate the asymmetry effect of bad news on Chinese stock volatility with a partial adjustment process. They find that the asymmetry effect begins to appear in May 1996. Dividing the total sample into two periods, Huang and Zhu (2004) produce results from the EGARCH and GJR models showing that the asymmetry effect only exists in the period between February 2001 and September 2003.

Spillover effects from the advanced to the other markets can be captured by examining the interdependence of these markets. With respect to the relationship between stock returns and volatilities, Beirne et al. (2013), Luca et al. (2006), Karolyi (1995), Lin, Engle, and Ito (1994), among others employed multivariate GARCH models in order to investigate the connectedness between the US and other countries. For instance, Long et al. (2014) and Johansson and Ljungwall (2009) evidenced no spillover effects from the US to China. In contrast, Moon and Yu (2010) found evidence of a volatility spillover effect from the US to China. On the other hand, Diebold and Yilmaz (2009) employed a variance decomposition using a VAR model to find the change in spillovers over time.

Asymmetric spillovers are relatively rarely investigated. Using an asymmetric multivariate GARCH, Li and Giles (2015) reveals asymmetry in the spillovers between the US and several major Asian stock markets. Bae et al. (2008) emphasise spillovers can be understated if asymmetry is ignored based on the US and Japanese stock markets. On the other hand, Baruník et al. (2016) use a realised semivariance-based measure to show an asymmetric spillover across the US stock sectors.

We test the presence of asymmetries on volatility and spillovers using a series of univariate and multivariate GARCH models on the daily return series for 74 markets (22 advanced markets 23 emerging and 29 frontier markets) for the period of January 2000[2] to July 2016. Their relationship with the level of market development is examined in the separate regression model. First, two univariate GARCH models, EGARCH and asymmetric CGARCH, are employed to examine the asymmetric volatility. Second, the variance decomposition of a vector-autoregressive model (VAR) is used to find the degree of spillovers from the US stock markets and their changes over time in terms of the proportional contribution to forecast errors. Third, a multivariate GARCH model, specifically an asymmetric full BEKK model, is combined with VAR, EGARCH and CGARCH models to investigate volatility and shock spillovers from the US stock market to the individual market and their asymmetry i.e. cross-border leverage effects. Finally, the estimated asymmetry parameters are regressed on the level of market development and control variables.

The contribution of this paper is fourfold. First, this paper provides evidence that market development could complementarily explain the asymmetries in addition to the leverage effect and the volatility feedback hypotheses. Second, it is also the first study that provides a comparative analysis of asymmetries in volatility and spillovers in the context of all advanced, emerging and frontier stock markets. The closest study is that of Beirne et al. (2013) which uses a full-BEKK to examine the spillovers to 41 emerging and frontier markets, but it failed to investigate the asymmetries in either volatility or spillovers. The studies of asymmetric spillovers by Baruník et al. (2016) and Bae et al. (1994) cover one single market. Third, the frontier market research, in this regard, is in its infancy. We provide initial empirical evidence on not only asymmetric volatility and spillovers on their stock returns, but also general connectedness to the global-leading US stock market in terms of returns and volatilities. Last, as part of the robustness test, the impact of the financial crisis on volatilities, spillovers and their asymmetry is investigated.

[2] Later start dates for some frontier markets are used due to data unavailability.

Our results show that the asymmetries in volatility and spillovers are linked to market development. First, asymmetric volatility almost universally exists in the advanced and the emerging markets (on average 99% and 87%), but is a less common phenomenon (64%) in the frontier markets. Second, the spillovers from the US to the other advanced and emerging markets are responsible for around 22% and 10% of forecast errors in each market, respectively, but less than 3% in the frontier markets no matter whether a positive or a negative impact on volatility. Third, asymmetries in the shock spillovers are observed in a higher proportion of the advanced and the emerging markets than the frontier markets, which shows that the volatility in the latter markets more symmetrically responds to the US shocks. Last, the positive link is revealed between the degrees of asymmetries and trading volume per GDP as the level of market development. On the other hand, a jump in the spillovers is observed at the time of the 2008 financial crisis across all three groups of markets but the post-crisis data generally confirms the robustness of the findings.

The remainder of the paper is structured as follows. Section 2 discusses the methodology including GARCH-family models. Section 3 describes the sample data and their statistical characteristics. The discussion of the estimated results is presented in Section 4. Section 5 provides concluding remarks.

2. Methodology

The Exponential GARCH (EGARCH) and the asymmetric Component GARCH (CGARCH) models are first employed to estimate the asymmetric responses of the volatility to own positive or negative return shocks to single stock markets. These univariate volatility models, using parsimonious order of 1, are combined with the best ARMA (autoregressive moving-average) model of return for each market based on Schwarz Information Criterion. Then, the significance of estimated parameters for asymmetry is tested.

The EGARCH and the CGARCH models are all based on the widely-used GARCH (generalised autoregressive conditional heteroscedasticity) models, originally developed by Bollerslev (1986). The conditional variance of the normally-distributed zero-mean shocks, $\epsilon_t \sim N(0, \sigma_t^2)$, is modelled as:

$$\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \tag{1}$$

where, $\omega > 0$ and $\alpha_i \geq 0$ and $\beta_j \geq 0$ to eliminate the possibility of negative variance.

However, this original GARCH model is symmetric in the sense that the conditional variance depends on the magnitudes of the lagged shocks, not their sign. This is in contrast to the stylised fact that negative shocks (bad news) tend to have a larger impact on volatility than positive shocks (good news) of the same magnitude. In other words, the response of volatility to positive and negative shocks is asymmetric, i.e. the asymmetric volatility, which is also commonly referred to as the leverage effect (Zivot 2008).

The EGARCH model of Nelson (1991) can accommodate asymmetric volatility in the following way, e.g. EGARCH(1,1):

$$ln(\sigma_t^2) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta ln(\sigma_{t-1}^2) \tag{2}$$

The presence of asymmetric volatility can be tested by the hypothesis that $\gamma < 0$. If $\gamma < 0$, negative shocks ($\epsilon_{t-1} < 0$) lead an increase in volatility relatively large to positive shocks. If $\gamma = 0$, the model becomes symmetric. Unlike the original GARCH models, the EGARCH specifies the conditional variance as an exponential function and thus removes the need for constraints to ensure positive definiteness (Hou 2013).

An asymmetric component GARCH (CGARCH) model combines the original component GARCH (Engle & Lee 1999) with a threshold term similar to the GJR GARCH (Glosten et al. 1993) to account for both long memory and asymmetry in volatility. For example, the asymmetric CGARCH(1,1) is specified as:.

$$\sigma_t^2 - m_t = \alpha(\epsilon_{t-1}^2 - m_{t-1}) + \gamma'(\epsilon_{t-1}^2 - m_{t-1})d_{t-1} + \beta(\sigma_{t-1}^2 - m_{t-1}) \quad (3)$$

$$m_t = \omega + \rho(m_{t-1} - \omega) + \phi(\epsilon_{t-1}^2 - \sigma_{t-1}^2)$$

where m_t is the time-varying long-term volatility and d_{t-1} is the dummy variable for a negative shock, i.e., d=1 if $\epsilon_{t-1} < 0$ and d=0 otherwise. Positive γ' indicates the presence of transitory asymmetric volatility, particularly a negative shock having a larger impact than a positive shock. Note that the same set of constraints as the original GARCH is required for positive definiteness of variance.

On the other hand, the stock returns in the international markets are likely to be closely related to the US stock returns because the emerging and the frontier stock markets as well as the advanced stock markets may be strongly affected by the US stock markets. This study adopts a bivariate vector-autoregressive model (VAR) of return to control for this return relationship. A bivariate VAR model of return assumes that the mean returns of one market are affected by own previous returns as well as the previous returns of the other market. The interaction between the returns in the international market (r_1) and the US market (r_2), using lag 1 of returns for simplicity, can be specified as:

$$\begin{bmatrix} r_{1,t} \\ r_{2,t} \end{bmatrix} = \begin{bmatrix} \delta_{10} \\ \delta_{20} \end{bmatrix} + \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{bmatrix} \begin{bmatrix} r_{1,t-1} \\ r_{2,t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \end{bmatrix} \quad (4)$$

where $\epsilon_t \sim N(0, \sigma_t^2)$ and $\text{cov}(\epsilon_1, \epsilon_2) = 0$. δ_{12} shows the effect of the US returns on the return of another single market.

Also, a shock to the US markets could be transferred to the other markets and cause a change in their volatilities, i.e. spillovers. The cross-variance shares from the variance decomposition of VAR models measure the spillovers based on how much the forecast errors in one market are caused by the US market. According to Diebold and Yilmaz (2009), one-step forecast errors ($e_{i,t+1}$) from a bivariate VAR are decomposed into:

$$\begin{bmatrix} e_{1,t+1} \\ e_{2,t+1} \end{bmatrix} = \begin{bmatrix} r_{1,t+1} - r_{1,t+1|t} \\ r_{2,t+1} - r_{2,t+1|t} \end{bmatrix} = \begin{bmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{bmatrix} \begin{bmatrix} \epsilon_{1,t+1} \\ \epsilon_{2,t+1} \end{bmatrix} \quad (5)$$

where $r_{i,t+1|t}$ is the forecasted returns for t+1 conditional on the information set at time t. The spillovers are represented by ψ_{12} and ψ_{21}. Particularly, the spillover from the US shocks (ϵ_2) is represented by ψ_{12}. Then, the variance of the forecast errors in forecasting the returns in non-US markets is $\psi_{11}^2 + \psi_{12}^2$. Finally, the cross-variance share (Diebold & Yilmaz 2009), a proportion of the variances caused by the US shocks as a measure of the spillover effect, for the non-US market is calculated as:

$$S_1 = \frac{\psi_{12}^2}{\psi_{11}^2+\psi_{12}^2} \tag{6}$$

Additionally, the change in the cross-variance shares over time is measured by a moving-window forecasting of VAR models in equation (4). After an initial estimation of the VAR model on the first 200 observations, ten forecasts are made and their cross-variance shares are calculated. Then, the next ten actual observations are added and the process is repeated to obtain a series of cross-variance shares. Note that this forecasting does not employ a fixed window and actually uses all available information each time. The Granger causality tests of the causation from the US to the individual non-US markets are also conducted for comparison. Finally, the VAR model is combined with multivariate GARCH models to test whether asymmetry in the spillovers or cross-border leverage effects exist, i.e., negative shocks to the US markets are transferred to the other markets and increase their volatility more than positive shocks. First, it is assumed that the residuals from the VAR follow an EGARCH or a CGARCH process to account for own news shocks, past volatility and asymmetric volatility effects in each individual market as in the previous section. Then, a multivariate GARCH model, specifically an asymmetric full BEKK model, is employed to investigate asymmetric spillovers from the US stock market to the non-US markets. This model can also be used to test the shock and volatility spillovers separately.

A multivariate GARCH model assumes that a random error ϵ_t follows a zero-mean process with the covariances conditional on past information set Ω_{t-1}, i.e.

$$\epsilon_t|\Omega_{t-1} \sim N(0, H_t) \tag{7}$$

where H_t is a $n \times n$ matrix of conditional covariances (h_{ij}) and n is the number of dependent variables. This study employs the full BEKK model (Engle & Kroner 1995) since it overcomes the positive definiteness problem of the VECH model (Bollerslev et al. 1988) and does not require a parameter matrix to be diagonal or a scalar. In the bivariate case of the full BEKK model, n=2, the conditional covariance matrix (H) is represented as:

$$H_t = C_0'C_0 + A'\epsilon_{t-1}\epsilon_{t-1}'A + G'H_{t-1}G \tag{8}$$

where, ϵ_{t-1} is a vector of an unexpected shock, C_0 is a triangular matrix and A and G are matrices of parameters. When all the elements are shown,

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix}$$

$$= \begin{bmatrix} c_{11} & c_{21} \\ 0 & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & c_{21} \\ 0 & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \epsilon_{1,t-1}^2 & \epsilon_{1,t-1}\epsilon_{2,t-1} \\ \epsilon_{1,t-1}\epsilon_{2,t-1} & \epsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

$$+ \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \tag{9}$$

a_{21} in h_{11} represents a shock spillover (or a news effect) from the US market, and g_{21} in h_{11} shows a volatility spillover incoming from the past volatility of the US market. Note that the simpler diagonal BEKK cannot test these spillovers since off-diagonal elements of A and G are zero.

This model can be extended to test the asymmetric shock spillovers where a negative shock to the US market increases the volatility in the market of interest more than a positive US shock does. By adding an additional quadratic form (Kroner & Ng 1998), the asymmetric full BEKK model is specified:

$$H_t = C_0'C_0 + A'\epsilon_{t-1}\epsilon_{t-1}'A + G'H_{t-1}G + D'\eta_{t-1}\eta_{t-1}'D \tag{10}$$

where $\eta_{i,t} = \epsilon_{i,t} \times I_{i,t}$, I_t is an indicator variable which has a value of 1 if ε_t<0 and D is a matrix of parameters as:

$$D = \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} \tag{11}$$

Statistically significant and positive d_{21} in h_{11} represents asymmetric shock spillovers from the US market. The parameters in the asymmetric full BEKK can be estimated by the MLE method (Kroner & Ng 1998; Engle & Kroner 1995).

On the other hand, a simple linear regression model is built to investigate the relationship between the asymmetry in volatility and spillovers and the level of market development. The degree of asymmetries (AS) is simply measured by the estimated γ, γ' and $|d_{21}|$. The level of market development is proxied by stock trading volume per GDP (TR) considering the strong trading activities are required to generate the asymmetries, e.g., asymmetric volatility from leverage effects or volatility feedback. The market size is controlled for by market capitalisation per GDP (MC).

$$AS_i = \xi_0 + \xi_1 TR_i + \xi_2 MC_i + \upsilon_i \tag{12}$$

where ξ's are coefficients and ν is the error term. If the asymmetries are positively related to market development, ξ_1 will be negative and significant with estimated γ as TR and positive and significant with γ' and $|d_{21}|$.

3. Data

The data sets used in this study are MSCI (Morgan Stanley Capital International) stock indices comprising the geographical spreads of North America, Latin America, Europe, Africa, the Middle East, Asia and Pacific. A total of 74 stock market indices, grouped into 22 developed, 23 emerging markets and 29 frontier markets, are used. The sample period starts on 3rd January 2000 for all advanced, 21 emerging and 14 frontier markets. For the remaining series, the starting date varies due to unavailability of the data. All 74 series end on 8th July 2016. The post-crisis sub-sample (after 8 August 2007) is also analysed to investigate the impact of the financial crisis. Data were extracted from Datastream. Table 1 presents a list of markets and their associated time periods.

Insert Table 1 here

The daily returns (r) of these indices are computed as percentage log returns after excluding the holidays and the weekends. The summary statistics of the individual market returns are presented in Table 2 and those of three groups of the markets, the advanced, the emerging and the frontier markets, are in Table 3. The corresponding trading volume (% of GDP) and market capitalization (% of GDP) data are obtained from the World Federation of Exchanges database via World Bank, and summarized in Table 8 Panel A.

Insert Table 2 here

The correlations in Table 2 vary substantially. The highest correlation with the U.S. market is shown for Canada, Brazil and Malaysia. All the emerging markets are moderately correlated with the U.S. market. In contrast, 12 out of 29 frontier markets are not statistically correlated with the U.S. market. This supports the findings of Kiviaho et al. (2014) and Berger et al. (2011a) who report that frontier markets' assets are less correlated with the global market, hence a good diversification option for international investors.

Insert Table 3 here

The emerging market has the highest daily average return (0.020%), followed by frontier (0.018%) and advanced (-0.002%) markets. The unconditional volatility of stock return measured by standard deviations is highest in emerging markets. The return distribution for all series are left skewed and highly leptokurtic as commonly observed in financial data such as by Canarella & Pollard (2007) and Dueker (1997). Therefore, the use of GARCH models seems appropriate to accommodate the statistical feature of leptokurtic. Note that the Augmented Dickey-Fuller (ADF), the Ng-Perron and the Phillips-Perron (PP) unit root tests confirm the stationarity of all the return series.

4. Empirical results

Table 4A and 4B present the estimation results of EGARCH (Table 4A) and CCARGH (Table 4B) models for individual markets over the entire sample period and the sub-sample of post-crisis[3]. The EGARCH results reveal that the estimated coefficients for the asymmetry term ($\boldsymbol{\gamma}$) are statistically significant and negative in all advanced and emerging markets both in the full sample and post-crisis period. This indicates the existence of asymmetric volatility. That is, negative shocks such as bad news in the financial market or adverse change in economic policies increase volatility in the stock returns more so than good news. This result supports the findings of Christensen et al. (2015b), Long et al (2014), Smith (2016) and Huang and Zhu (2004) in various advanced and emerging markets.

Insert Table 4A here

Insert Table 4B here

In contrast, only 19 and 23 out of 29 frontier markets show asymmetric response to negative shocks during full and post-crisis periods, respectively. On the other hand, estimated β's are dominantly larger than α, which indicates long-term persistence of volatilities in all advanced, emerging and frontier markets. It may necessitate the use of CGARCH models.

The CGARCH results confirm the EGARCH findings, albeit slightly weakly for the emerging markets. The asymmetry term ($\boldsymbol{\gamma}'$) is statistically significant and positive in all advanced markets during full and post-crisis periods, except Ireland in the full sample period. In the case of emerging markets, 18 and 16 out of 23 markets show evidence of the asymmetric volatility in full and post-crisis periods, respectively. In contrast, only 13 and 19 out of 29 frontier

[3]Due to space restriction, the best ARMA specification and the values of estimated constants, log likelihood, Q-statistics and SIC are not presented. These results are available upon request.

markets do so in full and post-crisis sample periods, respectively. Table 5 summarises the findings in Table 4A, 4B and 4C.

Insert Table 5 here

The degree of spillovers, measured by cross-variance shares (Table 6), shows that the advanced markets are most susceptible to the US shocks followed by the emerging and the frontier markets. On average, about 22% of the variance of forecast errors in the advanced markets are caused by the US shocks, but around 10% in the emerging markets and less than 3% in the frontier markets. It seems that as the stock markets are more developed and integrated into the global markets, they become more exposed to the shocks from the leading markets like the US.

Insert Table 6 here

Insert Figure 1 here

A strong spillover jump after the global financial crisis is observed in late 2008 (Figure 1) in all three groups, on average from 11.1% to 12.6%. The absolute size of the spillover jumps are the largest in the advanced markets (2.7% point) while the relative increase is the largest in the frontier markets (52%) although negligible. The spillover jump may reflect the stock investors' increased awareness of the affairs in the US stock markets once having experienced the global financial crisis. This change is not observed in the results of the pairwise Granger causality (Table 6), which do not show any strong evidence of increased impact of the US markets after the crisis, in terms of returns.

Insert Table 7 here

The estimation result of asymmetry in the spillovers is summarised in Table 7 as the percentage of the markets with significant corresponding estimates in each group[4]. First, a positive relationship ($\delta_{12} > 0$) exists between the past US returns and the returns of the non-US markets.

[4] See Appendix for the results for all individual stock markets.

The relatively weak link of the frontier markets could be due to the smaller number of foreign traders.

Second, asymmetric volatility (γ<0 or γ'>0) is also confirmed in a more general multivariate setup even after controlling for the spillovers. It is overall weaker in the frontier markets, despite a slight increase in the post-crisis period. The CGARCH results even show that negative shocks have a lower impact on volatility than positive shocks in many frontier markets.

Third, the shock spillovers, the significant response of volatility of non-US markets (a_{21}) to the shocks in the US markets, are observed in all three groups of the markets; however, whether the US shocks increase (a_{21}>0) or decrease (a_{21}<0) the volatility of the recipient non-US markets is not clear, particularly in the entire sample period. That is, in a large number of the markets, the US shocks actually reduce their volatilities.

Fourth, the asymmetry in the spillovers (d_{21}) exists in most of the stock markets, but relatively weakly in the frontier markets. However, unlike asymmetric volatility, whether negative US shocks have a stronger (d_{21}>0) or weaker (d_{21}<0) impact than positive US shocks on the volatility of the recipient markets is not clear. Last, the US volatility is also spread to the non-US markets and it mostly has a positive relationship (g_{21}>0). It is moderately weaker in the frontier markets.

The extra analysis using the post-crisis sub-sample data generally confirms the robustness of the findings, but several differences exist. First, the frontier markets showed a slightly higher degree of asymmetric volatility after the crisis but still lower than the other markets. Second, the shocks from the US market have slightly stronger impacts on the volatility of the other markets. Third, the past volatility of the US market positively affects the volatility of the other markets (g_{21}>0) in a larger number of markets in the post-crisis data. These two points may be evidence of stronger post-crisis international integration. Fourth, the US shocks are more likely to reduce the volatilities (a_{21}<0) in the emerging and the frontier markets after the crisis. Last, the negative US shocks are likely to have smaller or more negative impact than the positive US shocks ($d_{21}<0$) in all three groups of the markets, at least in the EGARCH results. The last two points could mean better market regulations were introduced in both sides of the shock transfers after the crisis, particularly about the market responses to adverse news shocks.

Overall, the results show that the asymmetries may grow more strongly as the stock markets mature. That is, market development could be at least partly responsible for the asymmetry in volatility and spillovers. For example, both the leverage effect hypothesis and the volatility feedback hypothesis require active traders who can adjust their prices based on increased risk from higher debt ratio or expected volatility for given negative shocks. However, the frontier markets may lack such traders and thus respond indifferently to positive and negative shocks. Also, they have a lower number of foreign traders who are more likely to transfer shocks and volatilities from overseas stock markets.

Insert Table 8 here

Table 8 presents the supporting evidence from the regression of the simple empirical model for asymmetries where the estimated parameters of asymmetric volatility ($\hat{\gamma}$ or $\hat{\gamma}'$) or shock spillovers ($\hat{d}_{21}$) are regressed on the trading volume per GDP with the market capitalisation per GDP as a control variable. The asymmetric volatility is indeed positively linked to the level of market development in all and the advanced markets (Panel B). Asymmetric shock spillovers in absolute value are also positively related with the market development in all, the advanced and the emerging markets (Panel C). These relationships are stronger in post-crisis data.

5. Conclusion

This paper examined the asymmetry in volatility and spillovers in stock returns of advanced, emerging and frontier markets in relation to the US market and captured the relationship between the asymmetry and market development. We employed univariate and multivariate asymmetric volatility models, cross-variance share and the simple model for the impact of market development on the asymmetries.

The results show that both asymmetries and spillovers are positively linked to market development from descriptive and analytical evidence. Asymmetric volatility is present almost universally in the advanced and the emerging stock markets, on average 99% and 87%. In contrast, it is not a common phenomenon in the frontier markets (64%). A spillover jump is observed after the financial crisis across all three groups of the markets. However, the degree of shock spillovers is lower in the frontier markets (3%) than the other two groups (22% and 10%, respectively); however, whether the shock spillovers from the US have positive or negative impacts on the volatility of the recipient markets is not clear as more markets experience volatility-decreasing US shocks. Asymmetry in the shock spillovers is also observed globally but again more weakly in the frontier markets. The impact of the negative US shocks on the volatilities of the local markets is more likely to be smaller than the positive shocks after the financial crisis. On the other hand, the simple regression model for asymmetries supports the positive relationship between the asymmetries and the level of market development.

This study has contributed toward a better understanding of the asymmetry in volatilities in advanced, emerging and frontier markets as well as the spillovers and their asymmetry between the US and the non-US stock markets. The understanding of the asymmetry is important in the issues of international portfolio management, asset allocation, risk-hedging and stock option valuation. Although this study has presented some empirical evidence of the relationship between the market development and the asymmetries in volatility and spillovers, further research could enhance the understanding of how the asymmetries are generated.

References

Abdalla, S.Z.S., 2012. Modelling Exchange Rate Volatility using GARCH Models: Empirical Evidence from Arab Countries. *International Journal of Economics and Finance*, 4(3), pp.1206–1214.

Abidi, N. et al., 2016. Changing Times for Frontier Markets: A Perspective from Portfolio Investment Flows and Financial Integration Changing Times for Frontier Markets: A Perspective from Portfolio Investment Flows and Financial Integration 1.

Abou-Zaid, A., 2011. Volatility Spillover Effects in Emerging Mena Stock Markets. *Review of Applied Economics*, 7(1).

Asai, M. & Brugal, I., 2013. Forecasting volatility via stock return, range, trading volume and spillover effects: The case of Brazil. *North American Journal of Economics and Finance*, 25, pp.202–213. Available at: http://dx.doi.org/10.1016/j.najef.2012.06.005.

Badshah, I. et al., 2016. Asymmetries of the intraday return-volatility relation. *International Review of Financial Analysis*, pp.1–11. Available at: http://linkinghub.elsevier.com/retrieve/pii/S105752191630151X.

Bae, K.-H. & Andrew Karolyi, G., 1994. Good news, bad news and international spillovers of stock return volatility between Japan and the U.S. *Pacific-Basin Finance Journal*, 2(4), pp.405–438.

Bae, K.-H., Yamada, T. & Ito, K., 2008. Interaction of investor trades and market volatility: Evidence from the Tokyo Stock Exchange. *Pacific-Basin Finance Journal*, 16(4), pp.370–388. Available at: http://www.sciencedirect.com/science/article/B6VFF-4PXM68X-2/1/cd62b3c7085f700e2a5d06b28fbb18dc.

Baruník, J., Kočenda, E. & Vácha, L., 2016. Asymmetric connectedness on the U.S. stock market: Bad and good volatility spillovers. *Journal of Financial Markets*, 27, pp.55–78.

Baumöhl, E. & Lyócsa, Š., 2014. Volatility and dynamic conditional correlations of worldwide emerging and frontier markets. *Economic Modelling*, 38, pp.175–183.

Beirne, J. et al., 2013. Volatility Spillovers and Contagion from Mature to Emerging Stock Markets. *Review of International Economics*, 21(5), pp.1060–1075. Available at: http://dx.doi.org/10.1111/roie.12091.

Berger, D., Pukthuanthong, K. & Jimmy Yang, J., 2011a. International diversification with frontier markets. *Journal of Financial Economics*.

Berger, D., Pukthuanthong, K. & Jimmy Yang, J., 2011b. International diversification with frontier markets. *Journal of Financial Economics*, 101(1), pp.227–242. Available at: http://dx.doi.org/10.1016/j.jfineco.2011.02.009.

Black, F., 1976. Studies of stock price volatility changes. In *Proceedings of the 1976 Meetings of the American Statistical Association, Business and Economical Statistics Section*. pp. 177–181.

Bley, J. & Saad, M., 2012. Idiosyncratic risk and expected returns in frontier markets: Evidence from GCC. *Journal of International Financial Markets, Institutions and Money*.

Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), pp.307–327.

Bollerslev, T., Engle, R.F. & Wooldridge, J.M., 1988. A Capital Asset Pricing Model with Time-Varying Covariances. *Journal of Political Economy*, 96(1), pp.116–131. Available at: http://www.jstor.org/stable/1830713.

Campbell, J.Y. & Hentschel, L., 1992. No News is Good News: An Asymmetric Model of Changing Volatility in Stock Returns. *Journal of Financial Economics*, 31, pp.281–318. Available at: http://www.nber.org/papers/w3742.

Canarella, G. & Pollard, S., 2007. A switching ARCH (SWARCH) model of stock market volatility: some evidence from Latin America. *International Review of Economics*, 54(4), pp.445–462. Available at: http://dx.doi.org/10.1007/s12232-007-0025-2.

Chen, G., Lee, C.F. & Rui, M.O., 2001. Stock Returns and Volatility of China Stock Markets. *The Journal of Financial Research*, 24(4), pp.523–543.

Chkili, W., Aloui, C. & Nguyen, D.K., 2012. Asymmetric effects and long memory in dynamic volatility relationships between stock returns and exchange rates. *Journal of International Financial Markets, Institutions and Money*, 22(4), pp.738–757. Available at: http://dx.doi.org/10.1016/j.intfin.2012.04.009.

Christensen, B.J., Nielsen, M.Ø. & Zhu, J., 2015a. The impact of financial crises on the risk–return tradeoff and the leverage effect. *Economic Modelling*, 49, pp.407–418. Available at: http://www.sciencedirect.com/science/article/pii/S0264999315000693.

Christensen, B.J., Nielsen, M.Ø. & Zhu, J., 2015b. The impact of financial crises on the risk–return tradeoff and the leverage effect. *Economic Modelling*, 49, pp.407–418.

Christie, A.A., 1982. The stochastic behavior of common stock variances : Value, leverage and interest rate effects. *Journal of Financial Economics*, 10(4), pp.407–432. Available at: http://www.sciencedirect.com/science/article/B6VBX-45KNM0P-57/2/bfff28ad0e1b3292eb2608a018c9bfc1.

Diebold, F.X. & Yilmaz, K., 2009. Measuring Financial Asset Return and Volatility Spillovers, With Application To Global Equity Markets. *The Economic Journal*, 119(534), pp.158–171.

Dueker, M., 1997. Markov Switching in GARCH Processes and Mean- Reverting Stock-Market Volatility. *Journal of business & Economics Statistics*, 15(1), pp.26–34.

Engle, R. & Lee, G.G.J., 1999. A Permanent and Transitory Component Model of Stock Return Volatility. In R. F. Engle & H. White, eds. *Cointegration, Causality, and Forecasting: A Festschrift in Honour of Clive W. J. Granger*. Oxford, UK: Oxford University Press, pp. 475–97.

Engle, R.F. & Kroner, K.F.., 1995. Multivariate Simultaneous Generalized Arch. *Econometric Theory*, 11(1), pp.122–150.

Engle, R.F. & Ng, V.K., 1993. Measuring and Testing the Impact of News on Volatility. *The Journal of Finance*, 48(5), pp.1749–1778.

French, K.R., Schwert, G.W. & Stambaugh, R.F., 1987. Expected stock returns and volatility.

Journal of Financial Economics, 19(1), pp.3–29. Available at: http://www.sciencedirect.com/science/article/pii/0304405X87900262.

Friedmann, R. & Sanddorf-Köhle, W.G., 2002. Volatility clustering and nontrading day in Chinese stock markets. *Journal of Economics and Business*, 54, pp.193–217.

Garcia, R. & Tsafack, G., 2011. Dependence structure and extreme comovements in international equity and bond markets. *Journal of Banking and Finance*, 35(8), pp.1954–1970.

Glosten, L.R., Jagannathan, R. & Runkle, D.E., 1993. On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks. *The Journal of Finance*, 48(5), pp.1779–1801.

Hou, A.J., 2013. Asymmetry effects of shocks in Chinese stock markets volatility: A generalized additive nonparametric approach. *Journal of International Financial Markets, Institutions and Money*, 23(1), pp.12–32. Available at: http://dx.doi.org/10.1016/j.intfin.2012.08.003.

Huang, W.-C. & Zhu, Y., 2004. Are Shocks Asymmetric to Volatility of Chinese Stock Markets? *Review of Pacific Basin Financial Markets and Policies*, 7(3), pp.379–395. Available at: http://dx.doi.org/10.1142/S0219091504000159.

Johansson, A.C. & Ljungwall, C., 2009. Spillover Effects Among the Greater China Stock Markets. *World Development*, 37(4), pp.839–851. Available at: http://dx.doi.org/10.1016/j.worlddev.2008.07.015.

Karolyi, A., 1995. A Multivariate GARCH Model of International Transmissions of The Case of the United States and Canada Stock Returns and Volatility : *Journal of Business & Economic Statistics*, 13(1), pp.11–25.

Kiviaho, J. et al., 2014. The Co-movement Dynamics of European Frontier Stock Markets. *European Financial Management*, 20(3), pp.574–595.

Kristoufek, L., 2014. Leverage effect in energy futures. *Energy Economics*, 45, pp.1–9. Available at: http://dx.doi.org/10.1016/j.eneco.2014.06.009.

Kroner, K.F. & Ng, V.K., 1998. Modeling Asymmetric Comovements of Asset Returns. *Review of Financial Studies*, 11(4), pp.817–844.

Li, Y. & Giles, D.E., 2015. Modelling volatility spillover effects between developed stock markets and Asian emerging stock markets. *International Journal of Finance and Economics*, 20(2), pp.155–177.

Lin, W.-L., Engle, R.F. & Ito, T., 1994. Do Bulls and Bears Move Across Borders? International Transmission of Stock Returns and Volatility. *Review of Financial Studies* , 7(3), pp.507–538. Available at: http://rfs.oxfordjournals.org/content/7/3/507.abstract.

Long, L., Tsui, A.K. & Zhang, Z., 2014. Conditional heteroscedasticity with leverage effect in stock returns: Evidence from the chinese stock market. *Economic Modelling*, 37, pp.89–102. Available at: http://dx.doi.org/10.1016/j.econmod.2013.11.002.

Luca, G. De, Genton, M.G. & Loperfido, N., 2006. A multivariate skew-garch model.

Advances in Econometrics, 20 PART 1, pp.33–57.

Moon, G.-H. & Yu, W.-C., 2010. Volatility Spillovers between the US and China Stock Markets: Structural Break Test with Symmetric and Asymmetric GARCH Approaches. *Global Economic Review*, 39(2), pp.129–149.

Nelson, D.B., 1991. Conditional Heteroskedasticity in Asset Returns: A New Approach. *Econometrica*, 59(2), pp.347–370. Available at: http://links.jstor.org/sici?sici=0012-9682(199103)59:2%3C347:CHIARA%3E2.0.CO;2-V.

Pindyck, R.S., 1984. Risk, Inflation, and the Stock Market. *The American Economic Review*, 74(3), pp.335–351. Available at: http://www.jstor.org/stable/1804011.

Samarakoon, L.P., 2011. Stock market interdependence, contagion, and the U.S. financial crisis: The case of emerging and frontier markets. *Journal of International Financial Markets, Institutions and Money*.

Smith, G.P., 2015. New Evidence on Sources of Leverage Effects in Individual Stocks. *The Financial Review*, 50, pp.331–340.

Smith, G.P., 2016. Weekday variation in the leverage effect: A puzzle. *Finance Research Letters*, 17, pp.193–196. Available at: http://dx.doi.org/10.1016/j.frl.2016.03.001.

United Nations, 2014. World Economic Situation Prospects. Available at: http://www.un.org/en/development/desa/policy/wesp/wesp_current/wesp2014.pdf.

Wang, X., Wu, C. & Xu, W., 2015. Volatility forecasting: The role of lunch-break returns, overnight returns, trading volume and leverage effects. *International Journal of Forecasting*, 31(3), pp.609–619. Available at: http://dx.doi.org/10.1016/j.ijforecast.2014.10.007.

Zhang, B. & Li, X., 2008. The asymmetric behaviour of stock returns and volatilities: evidence from Chinese stock market. *Applied Economics Letters*, 15(12), pp.959–962. Available at: http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,shib&db=bth&AN=34612084&scope=site.

Zivot, E., 2008. Practical Issues in the Analysis of Univariate GARCH Some Stylized Facts of Asset Returns. *Time*, pp.1–41. Available at: http://faculty.washington.edu/ezivot/research/practicalgarchfinal.pdf.

Table 1. List of Sample Countries

Advanced	Date	Emerging	Date	Frontier	Date
Australia	3/1/00-8/7/16	Brazil	3/1/00-8/7/16	Argentina	3/1/00-8/7/16
Austria	3/1/00-8/7/16	Chile	3/1/00-8/7/16	Bahrain	31/5/02-8/7/16
Belgium	3/1/00-8/7/16	China	3/1/00-8/7/16	Bangladesh	3/1/00-8/7/16
Canada	3/1/00-8/7/16	Colombia	3/1/00-8/7/16	Bosnia Herzegovina	30/11/10-8/7/16
Denmark	3/1/00-8/7/16	Czech Rep.	3/1/00-8/7/16	Botswana	25/11/08-8/7/16
Finland	3/1/00-8/7/16	Egypt	3/1/00-8/7/16	Bulgaria	20/10/00-8/7/16
France	3/1/00-8/7/16	Greece	3/1/00-8/7/16	Croatia	3/1/00-8/7/16
Germany	3/1/00-8/7/16	Hungary	3/1/00-8/7/16	Estonia	31/5/02-8/7/16
Hong Kong	3/1/00-8/7/16	India	3/1/00-8/7/16	Ghana	25/11/08-8/7/16
Ireland	3/1/00-8/7/16	Indonesia	3/1/00-8/7/16	Jamaica	3/1/00-8/7/16
Israel	3/1/00-8/7/16	Korea	3/1/00-8/7/16	Jordan	3/1/00-8/7/16
Italy	3/1/00-8/7/16	Malaysia	3/1/00-8/7/16	Kazakhstan	30/11/05-8/7/16
Japan	3/1/00-8/7/16	Mexico	3/1/00-8/7/16	Kenya	3/1/00- 8/7/16
Netherland	3/1/00-8/7/16	Peru	3/1/00-8/7/16	Lithuania	30/11/10-8/7/16
New Zealand	3/1/00-8/7/16	Philippines	3/1/00-8/7/16	Mauritius	31/05/02-8/7/16
Norway	3/1/00-8/7/16	Poland	3/1/00-8/7/16	Morocco	3/1/00-8/7/16
Portugal	3/1/00-8/7/16	Qatar	31/5/05-8/7/16	Nigeria	14/1/00-8/7/16
Singapore	3/1/00-8/7/16	Russia	3/1/00-8/7/16	Oman	3/1/00-8/7/16
Spain	3/1/00-8/7/16	South Africa	3/1/00-8/7/16	Pakistan	3/1/00-8/7/16
Sweden	3/1/00-8/7/16	Taiwan	3/1/00-8/7/16	Palestine	26/9/13-8/7/16
Switzerland	3/1/00-8/7/16	Thailand	3/1/00-8/7/16	Romania	30/11/05-8/7/16
UK	3/1/00-8/7/16	Turkey	3/1/00-8/7/16	Serbia	30/05/08-8/7/16
		UAE	31/5/05-8/7/16	Slovenia	30/5/02-8/7/16
		Ukraine	3/1/00-8/7/16	Sri Lanka	3/1/00-8/7/16
		Vietnam	28/7/00-8/7/16	Trinidad & Tobago	3/1/00-8/7/16
		Zimbabwe	30/11/10-8/7/16	Tunisia	3/1/00-8/7/16

Note: Ukraine, Vietnam and Zimbabwe are the frontier markets.

Table 2. Descriptive Statistics – Individual Markets

Advanced	Mean	SD	cor	**Emerging**	Mean	SD	cor	**Frontier**	Mean	SD	cor
Australia	0.012	1.038	0.218	Brazil	0.030	1.685	0.639	Argentina	0.043	2.278	0.449
Austria	-0.001	1.564	0.417	Chile	0.021	1.003	0.508	Bahrain	-0.013	1.042	0.092
Belgium	0.000	1.377	0.403	China	0.011	1.815	0.295	Bangladesh	0.048	1.579	-0.047‡
Canada	0.013	1.199	0.993	Colombia	0.058	1.300	0.394	Bosnia Herzegovina	-0.030	1.280	-0.025‡
Denmark	0.041	1.435	0.336	Czech Rep.	0.018	1.480	0.362	Botswana	-0.010	0.757	-0.070‡
Finland	-0.010	2.143	0.424	Egypt	0.043	1.741	0.124	Bulgaria	0.037	1.525	0.043
France	-0.003	1.459	0.532	Greece	-0.053	1.896	0.283	Croatia	0.021	1.307	0.165
Germany	0.002	1.514	0.535	Hungary	0.012	1.732	0.395	Estonia	0.025	1.427	0.171
Hong Kong	0.008	1.341	0.266	India	0.038	1.543	0.297	Ghana	0.033	1.148	-0.033‡
Ireland	-0.019	1.701	0.369	Indonesia	0.044	1.684	0.212	Jamaica	0.046	0.782	-0.066
Israel	-0.042	1.771	0.318	Korea	0.039	1.659	0.190	Jordan	0.020	1.094	0.036
Italy	-0.017	1.526	0.489	Malaysia	0.016	0.883	0.626	Kazakhstan	-0.002	2.515	0.164
Japan	-0.012	1.413	0.212	Mexico	0.040	20.152	0.500	Kenya	0.012	1.387	-0.037‡
Netherland	-0.003	1.403	0.493	Peru	0.046	1.383	0.135	Lithuania	0.000	0.720	0.119
New Zealand	0.004	0.966	0.087	Philippines	0.022	1.386	0.396	Mauritius	0.051	1.010	0.033‡
Norway	0.005	1.873	0.469	Poland	-0.003	1.524	0.092	Morocco	0.004	0.907	-0.040
Portugal	-0.024	1.244	0.400	Qatar	-0.001	1.508	0.485	Nigeria	0.039	1.317	0.009‡
Singapore	-0.001	1.213	0.291	Russia	0.031	2.280	0.421	Oman	0.019	0.986	0.159
Spain	-0.007	1.559	0.474	South Africa	0.039	1.262	0.259	Pakistan	0.037	1.595	0.113‡
Sweden	0.002	1.600	0.489	Taiwan	-0.006	1.477	0.227	Palestine	0.005	0.687	0.085
Switzerland	0.001	1.177	0.457	Thailand	0.021	1.584	0.292	Romania	0.001	1.775	0.226
UK	-0.002	1.203	0.533	Turkey	0.035	2.223	0.342	Serbia	-0.058	1.788	0.105
				UAE	-0.015	1.938	0.142	Slovenia	0.006	1.258	0.061
				Ukraine	0.044	3.733	0.051	Sri Lanka	0.042	1.485	0.040‡
				Vietnam	0.046	1.513	0.079	Trinidad & Tobago	0.026	0.721	0.060‡
				Zimbabwe	-0.003	1.230	0.083‡	Tunisia	0.036	0.540	0.070‡

Note: Mean is an average percentage log returns, SD is their standard deviation and cor is the correlation coefficients with the US stock returns. ‡ indicates that correlation is insignificant at the 0.05 level.

Table 3. Descriptive Statistics – Advanced, Emerging and Frontier Markets

		Advanced	**Emerging**	**Frontier**
Mean		-0.002	0.020	0.018
Median		0.014	0.008	0.000
Maximum		10.713	53.144	15.426
Minimum		-11.861	-54.033	-16.350
Std. Dev.		1.442	2.397	1.358
Skewness		-0.290	-0.234	-0.037
Kurtosis		9.240	103.753	69.425
Probability		0	0	0
Observations		4,310	4,188	3,450
Unit root tests	ADF	100.00%	100.00%	100.00%
	NP	100.00%	100.00%	100.00%
	PP	100.00%	100.00%	100.00%

Note: Results are produced by averaging the results of all countries belong to advanced, emerging and frontier markets group. JB probability is the p-value for JB statistics. The unit root tests results are the percentage of the rejection of the hypothesis of unit roots in all the countries in each group. ADF, NP and PP are the augmented Dickey-Fuller tests, the Ng-Perron and the Phillips-Perron unit root tests, respectively. The detailed test results for individual markets can be provided on request.

Table 4A. Asymmetric volatility in individual markets - EGARCH results

Advanced	Full Period			Post -crisis		
Country	α	β	γ'	α	β	γ'
Australia	0.129	0.979	-0.101	0.139	0.978	-0.099
Austria	0.121	0.983	-0.086	0.098	0.983	-0.094
Belgium	0.139	0.978	-0.11	0.125	0.969	-0.119
Canada	0.111	0.989	-1.562	0.114	0.987	-0.11
Denmark	0.139	0.954	-0.046	0.192	0.927	-0.049
Finland	0.071	0.994	-0.052	0.065	0.986	-0.082
France	0.096	0.981	-0.127	0.109	0.969	-0.167
Germany	0.118	0.978	-0.118	0.124	0.972	-0.129
Hong Kong	0.107	0.986	-0.056	0.104	0.986	-0.061
Ireland	0.178	0.978	-0.071	0.178	0.983	-0.061
Israel	0.074	0.993	-0.027	0.075	0.994	-0.044
Italy	0.109	0.984	-0.107	0.12	0.97	-0.123
Japan	0.171	0.964	-0.09	0.176	0.959	-0.103
Netherland	0.121	0.98	-0.122	0.143	0.972	-0.142
New Zealand	0.078	0.992	-0.035	0.08	0.99	-0.033
Norway	0.128	0.977	-0.086	0.108	0.982	-0.099
Portugal	0.145	0.977	-0.088	0.132	0.964	-0.122
Singapore	0.152	0.987	-0.066	0.125	0.991	-0.077
Spain	0.106	0.982	-0.109	0.112	0.976	-0.126
Sweden	0.105	0.985	-0.097	0.107	0.985	-0.103
Switzerland	0.138	0.969	-0.135	0.163	0.959	-0.146
UK	0.12	0.981	-0.12	0.137	0.977	-0.131

Emerging	Full Period			Post -crisis		
Country	α	β	γ'	α	β	γ'
Brazil	0.122	0.979	-0.058	0.12	0.991	-0.068
Chile	0.194	0.966	-0.073	0.153	0.978	-0.088
China	0.136	0.985	-0.044	0.124	0.099	-0.053
Colombia	0.366	0.906	-0.057	0.256	0.938	-0.09
Czech Rep.	0.186	0.958	-0.071	0.167	0.968	-0.08
Egypt	0.107	0.965	-0.054	0.066	0.974	-0.082
Greece	0.07	0.997	-0.04	0.056	0.985	-0.052
Hungary	0.15	0.975	-0.049	0.158	0.979	-0.064
India	0.219	0.972	-0.085	0.163	0.989	-0.069
Indonesia	0.152	0.975	-0.062	0.121	0.986	-0.082
Malaysia	0.16	0.985	-0.062	0.182	0.979	-0.083
Mexico	0.638	0.423	-0.785	0.095	0.991	-0.089
Peru	0.267	0.964	-0.059	0.223	0.973	-0.061
Philippines	0.139	0.966	-0.064	0.156	0.972	-0.093
Poland	0.108	0.988	-0.04	0.11	0.988	-0.076
Qatar	0.16	0.988	-0.041	0.195	0.986	-0.048
Rep.of Korea	0.112	0.993	-0.055	0.082	0.989	-0.083
Russia	0.162	0.979	-0.055	0.123	0.987	-0.084
South Africa	0.138	0.98	-0.08	0.055	0.988	-0.118
Taiwan	0.098	0.989	-0.061	0.073	0.991	-0.065
Thailand	0.141	0.963	-0.064	0.147	0.983	-0.065
Turkey	0.138	0.986	-0.04	0.126	0.969	-0.072
UAE	0.144	0.978	-0.069	0.153	0.975	-0.083
Ukraine	0.807	0.852	-0.277	0.357	0.952	-0.024
Vietnam	0.351	0.957	-0.019	0.253	0.945	-0.049
Zimbabwe	0.183	0.926	0.023	0.184	0.926	0.023

Frontier	Full Period			Post -crisis		
Country	α	β	γ'	α	β	γ'
Argentina	0.196	0.956	-0.045	0.284	0.912	-0.079
Bahrain	0.242	0.932	0.008‡	0.078	0.978	-0.05
Bangladesh	0.009	0.941	-0.086	0.171	0.872	-0.159
Bosnia & H	0.078	0.978	-0.05	0.077	0.977	-0.049
Botswana	0.157	0.921	-0.06	0.157	0.921	-0.06
Bulgaria	0.287	0.984	-0.002	0.327	0.951	-0.037
Croatia	0.185	0.992	-0.009‡	0.157	0.991	-0.047
Estonia	0.213	0.973	0.011	0.239	0.971	-0.006
Ghana	0.224	0.914	-0.016	0.224	0.914	-0.016
Jamaica	0.241	0.922	0.047	0.181	0.969	0.024
Jordan	0.178	0.985	0.025	0.438	0.921	0.04
Kazakhstan	0.129	0.985	-0.058	0.145	0.978	-0.063
Kenya	0.239	0.969	-0.017	0.187	0.981	-0.009
Lithuania	0.252	0.922	-0.061	0.252	0.922	-0.061
Mauritius	0.346	0.951	0.013	0.224	0.988	-0.022
Morocco	0.315	0.898	-0.02	0.214	0.932	-0.031
Nigeria	0.425	0.941	0.144	0.275	0.924	0.006‡
Oman	0.264	0.92	-0.068	0.342	0.96	-0.056
Pakistan	0.316	0.943	-0.07	0.304	0.932	-0.126
Palestine	0.215	0.903	-0.003	0.216	0.901	-0.005‡
Romania	0.692	0.759	0.067	0.696	0.873	0.1
Serbia	0.25	0.964	-0.037	0.25	0.934	-0.037
Slovenia	0.173	0.974	-0.03	0.352	0.92	-0.083
Sri Lanka	0.142	0.997	-0.003‡	0.327	0.953	-0.026
Trinidad & T	0.155	0.988	-0.083	0.147	0.919	-0.19
Tunisia	0.264	0.939	-0.036	0.308	0.921	-0.063

Note: ‡ indicates the insignificance at 5% level. Ukraine, Vietnam and Zimbabwe are the frontier markets.

Table 4B. Asymmetric volatility in individual markets - CGARCH results

Advanced	Full Period			Post -crisis		
Country	α	β	γ’	α	β	γ’
Australia	-0.065	0.971	0.113	-0.054	0.031	0.036
Austria	0.009	0.894	0.088	-0.067	0.828	0.144
Belgium	-0.032	0.871	0.139	-0.015	0.881	0.132
Canada	-0.094	0.522	0.119	-0.142	0.414	0.095
Denmark	-0.006	0.817	0.125	-0.065	0.864	0.106
Finland	-0.002	0.049	0.081	0.013	0.062	0.006
France	-0.085	0.999	0.142	-0.125	0.053	0.121
Germany	-0.164	0.042	0.136	-0.164	0.317	0.161
Hong Kong	-0.044	0.138	0.012	0.024	0.932	0.049
Ireland	0.066	0.943	-0.023	0.011	0.809	0.127
Israel	-0.034	-0.259	0.012	-0.079	-0.347	0.057
Italy	-0.139	0.607	0.142	-0.15	1.097	0.084
Japan	-0.115	0.725	0.124	0.055	0.199	0.069
Netherland	-0.025	0.987	0.074	-0.037	0.887	0.139
New Zealand	0.024	0.779	0.053	0.017	0.727	0.061
Norway	-0.088	0.028	0.065	-0.105	0.098	0.049
Portugal	-0.054	0.734	0.017	-0.099	0.724	0.186
Singapore	-0.078	-0.053	0.063	0.086	0.847	0.09
Spain	-0.005	0.907	0.087	-0.304	1.215	0.106
Sweden	-0.039	0.912	0.108	0.04	0.931	0.04
Switzerland	-0.161	0.143	0.121	-0.157	0.08	0.144
UK	-0.163	0.026	0.163	0.027	0.927	0.115

Emerging	Full Period			Post -crisis		
Country	α	β	γ’	α	β	γ’
Brazil	-0.056	-0.217	0.022	-0.035	0.299	0.065
Chile	-0.077	0.999	0.092	-0.057	0.979	0.104
China	-0.067	0.067	0.087	-0.09	0.083	0.012
Colombia	0.112	0.858	-0.005‡	-0.083	0.122	0.122
Czech Rep.	-0.068	0.054	0.081	-0.059	0.033	0.148
Egypt	0.01	0.827	0.038	-0.087	-0.101	-0.012
Greece	0.086	0.811	0.004	-0.075	0.041	0.056
Hungary	-0.047	0.811	0.139	-0.07	0.783	0.188
India	-0.123	0.461	0.154	-0.123	0.442	0.028
Indonesia	0.084	0.844	0.022	-0.021	0.577	0.06
Malaysia	0.052	0.962	-0.032	0.062	0.112	-0.067
Mexico	0.197	0.678	0.006	0.058	-0.436	-0.094
Peru	0.142	0.748	0.022	0.026	0.779	0.074
Philippines	0.018	0.084	-0.077	0.039	0.051	-0.076
Poland	-0.049	0.056	0.093	-0.117	0.048	0.2
Qatar	0.027	0.872	0.064	0.078	0.228	-0.089
Rep.of Korea	-0.061	-0.493	0.033‡	-0.096	0.029	0.052‡
Russia	-0.048	-0.2	0.009‡	-0.048	-0.301	-0.004‡
South Africa	-0.095	-0.352	0.112	-0.114	-0.071	0.093
Taiwan	-0.086	0.023	0.067	-0.072	-0.771	0.091
Thailand	-0.017	0.758	0.066	-0.119	-0.253	0.091
Turkey	0.033	0.817	0.054	-0.087	0.034	0.129
UAE	-0.098	-0.108	0.067	-0.028	0.921	0.098
Ukraine	0.378	0.379	-0.102	0.112	0.725	0.066
Vietnam	0.091	0.355	0.062	-0.035	0.149	0.09
Zimbabwe	-0.022	0.241	0.483	-0.022	0.24	0.482

Frontier	Full Period			Post -crisis		
Country	α	β	γ’	α	β	γ’
Argentina	0.043	0.67	0.083	0.028	0.641	0.139
Bahrain	-0.036	0.119	-0.117	-0.037	-0.232	-0.127
Bangladesh	-0.122	0.078	0.062	-0.084	0.21	0.176
Bosnia & H	0.117	-0.257	-0.063	0.117	-0.257	-0.063
Botswana	-0.019	0.005	0.084	-0.019	0.005	0.087
Bulgaria	0.215	0.674	-0.019‡	0.056	0.313	0.028
Croatia	0.151	0.508	-0.061	0.121	0.884	-0.053
Estonia	0.257	0.107	-0.126	0.307	0.182	0.029
Ghana	0.179	0.396	-0.314	0.018	0.396	-0.314
Jamaica	0.149	0.036	-0.077	0.105	0.641	0.036‡
Jordan	0.16	0.589	-0.089	0.277	0.526	0.01
Kazakhstan	0.076	-0.041	0.052	0.107	0.76	-0.011
Kenya	0.196	0.422	-0.106	0.172	0.506	-0.036
Lithuania	-0.106	0.215	0.335	-0.105	0.214	0.335
Mauritius	0.249	0.392	0.107	0.229	0.28	0.059
Morocco	0.113	0.672	0.119	0.091	0.542	0.064
Nigeria	0.045	0.891	-0.077	0.129	0.412	0.015
Oman	0.323	0.23	-0.376	0.113	0.192	-0.139
Pakistan	-0.016	0.918	0.078	-0.127	0.938	0.129
Palestine	0.042	0.498	0.128	0.018	0.093	0.047
Romania	0.338	0.325	-0.032	0.04	0.016	0.04
Serbia	0.094	0.376	0.062	0.09	0.413	0.072
Slovenia	0.12	0.249	0.091	0.166	0.163	0.096
Sri Lanka	0.217	0.561	-0.071	0.125	0.499	0.035
Trinidad & T	0.037	0.642	-0.398	-0.002	0.108	-0.161
Tunisia	0.247	0.419	-0.045	0.312	0.226	-0.012

Note: ‡ indicates the insignificance at 5% level. Ukraine, Vietnam and Zimbabwe are the frontier markets.

Table 5: Asymmetric volatility - Summary results of individual markets

Markets	EGARCH		CGARCH		Average	Sample
	Full Period	Post-crisis	Full Period	Post-crisis		
Advanced	22 (100%)	22 (100%)	21 (95%)	22 (100%)	99%	22
Emerging	23 (100%)	23 (100%)	18 (78%)	16 (70%)	87%	23
Frontier	19 (66%)	23 (79%)	13 (45%)	19 (66%)	64%	29

Note: numbers and % values indicate the number and the percentage of the markets in the group that shows the significance of corresponding parameters at 5% significance level, respectively.

Table 6. Shock spillovers - cross-variance shares

Advanced	Full	Post	**Emerging**	Full	Post	**Frontier**	Full	Post
Australia	22.92 ^{C}	25.09 ^{C}	Brazil	26.56 ^{C}	34.46 ^{C}	Argentina	14.51	20.73
Austria	10.98 ^{C}	18.65 ^{C}	Chile	16.11 ^{C}	20.54 ^{C}	Bosnia & H	1.02 ^{C}	1.02 ^{C}
Belgium	13.86 ^{C}	16.99 ^{C}	China	13.02 ^{C}	15.87 ^{C}	Bahrain	0.45 ^{C}	0.73 ^{C}
Canada	97.57 ^{C}	98.46 ^{c}	Colombia	4.13 ^{C}	7.62 ^{C}	Bangladesh	0.34	0.04
Denmark	13.80 ^{C}	15.79 ^{C}	Czech Rep.	12.20 ^{C}	14.64 ^{C}	Botswana	0.20	0.20
Finland	19.13 ^{C}	19.73 ^{C}	Egypt	2.36 ^{C}	3.21 ^{C}	Bulgaria	1.17 ^{C}	2.20 ^{C}
France	27.02 ^{C}	30.10 ^{C}	Greece	8.50 ^{C}	10.07 ^{C}	Croatia	3.38 ^{C}	6.06 ^{C}
Germany	28.29 ^{C}	29.39 ^{C}	Hungary	12.94 ^{C}	15.25 ^{C}	Estonia	6.20 ^{C}	7.16 ^{C}
Hong Kong	15.25 ^{C}	16.91 ^{C}	India	6.64 ^{C}	8.53 ^{C}	Ghana	0.15 ^{c}	0.15 ^{c}
Ireland	11.95 ^{C}	14.82 ^{C}	Indonesia	4.14 ^{C}	7.23 ^{C}	Jamaica	0.37	0.58 ^{C}
Israel	18.08 ^{C}	12.09 ^{c}	Korea	12.74 ^{C}	13.15 ^{C}	Jorden	0.75 ^{C}	1.17 ^{C}
Italy	22.38 ^{C}	26.06 ^{C}	Malaysia	7.54 ^{C}	8.93 ^{C}	Kazakhstan	9.32 ^{C}	10.93 ^{C}
Japan	13.67 ^{C}	17.62 ^{C}	Mexico	0.25 ^{C}	0.28 ^{C}	Kenya	0.51 ^{C}	0.10 ^{C}
Netherlands	22.17 ^{C}	25.39 ^{C}	Peru	15.13 ^{C}	20.33 ^{C}	Lithuania	4.71 ^{C}	4.71 ^{C}
New Zealand	8.15 ^{C}	9.89 ^{C}	Philippines	7.45 ^{C}	10.63 ^{C}	Mauritius	0.55 ^{C}	0.89 ^{C}
Norway	18.65 ^{C}	25.70 ^{C}	Poland	12.88 ^{C}	14.34 ^{C}	Morocco	0.31 ^{C}	0.35 ^{C}
Portugal	15.08 ^{C}	17.34 ^{C}	Qatar	3.51 ^{C}	4.33 ^{C}	Nigeria	0.05 ^{C}	0.08 ^{C}
Singapore	11.84 ^{C}	14.07 ^{C}	Russia	14.40 ^{C}	18.84 ^{C}	Oman	1.13 ^{C}	2.08 ^{C}
Spain	20.86 ^{C}	23.75 ^{C}	S. Africa	18.02 ^{C}	19.92 ^{C}	Pakistan	0.85 ^{C}	0.66 ^{C}
Sweden	23.78 ^{C}	25.69 ^{C}	Taiwan	8.06 ^{C}	9.95 ^{C}	Palestine	1.09	1.09
Switzerland	17.33 ^{C}	22.40 ^{C}	Thailand	7.00 ^{C}	8.67 ^{C}	Romania	7.96 ^{C}	9.11 ^{C}
Uk	24.32 ^{C}	29.81 ^{C}	Turkey	5.40 ^{C}	7.15 ^{C}	Serbia	9.71 ^{C}	9.71 ^{C}
Average – AL	11.08	12.57	UAE	3.58 ^{C}	4.59 ^{C}	Slovenia	5.21 ^{C}	7.96 ^{C}
Average – AD	21.69	24.35	Ukraine	0.54 ^{C}	0.88 ^{C}	Sri Lanka	0.13 ^{C}	0.23 ^{C}
Average – EM	9.80	12.11	Vietnam	1.29 ^{C}	2.36 ^{C}	Trinidad & T	0.06	0.03
Average – FR	2.17	3.30	Zimbabwe	0.17	0.17	Tunisia	0.42 ^{C}	0.42 ^{C}

Note: The numbers show the percentage share of the variance of forecast errors in a non-US market caused by the shocks in the US market. “^{C}” and “^{c}” indicated the Granger causality in returns of 5 lags from the US to each non-US market at 5% and 10% significance level, respectively. “Average” shows the average of all cross-variance shares in the corresponding groups – all (AL), advanced (AD), emerging (EM) and frontier (FR) markets.

Table 7: Asymmetry in volatility and spillovers - asymmetric full BEKK results

Panel A: EGARCH

		Full-period				Post-Crisis				
		Pos		Neg		Pos		Neg		Total
RUS	AL	65	*87.8%*	3	*4.1%*	65	*87.8%*	1	*1.4%*	74
δ12	AD	21	*95.5%*	0	*0.0%*	21	*95.5%*	0	*0.0%*	22
	EM	22	*95.7%*	1	*4.3%*	22	*95.7%*	0	*0.0%*	23
	FR	22	*75.9%*	2	*6.9%*	22	*75.9%*	1	*3.4%*	29
Leverage	AL	6	*8.1%*	62	*83.8%*	3	*4.1%*	67	*90.5%*	74
γ	AD	0	*0.0%*	22	*100.0%*	0	*0.0%*	22	*100.0%*	22
	EM	0	*0.0%*	23	*100.0%*	0	*0.0%*	23	*100.0%*	23
	FR	6	*20.7%*	17	*58.6%*	3	*10.3%*	22	*75.9%*	29
Shock	AL	26	*35.1%*	23	*31.1%*	21	*28.4%*	34	*45.9%*	74
Spillover	AD	8	*36.4%*	6	*27.3%*	11	*50.0%*	6	*27.3%*	22
a21	EM	9	*39.1%*	7	*30.4%*	3	*13.0%*	16	*69.6%*	23
	FR	9	*31.0%*	10	*34.5%*	7	*24.1%*	12	*41.4%*	29
Asymmetric	AL	26	*35.1%*	19	*25.7%*	16	*21.6%*	36	*48.6%*	74
Shock	AD	9	*40.9%*	9	*40.9%*	4	*18.2%*	14	*63.6%*	22
Spillover	EM	7	*30.4%*	7	*30.4%*	3	*13.0%*	14	*60.9%*	23
d21	FR	10	*34.5%*	3	*10.3%*	9	*31.0%*	8	*27.6%*	29
Volatility	AL	32	*43.2%*	11	*14.9%*	40	*54.1%*	7	*9.5%*	74
Spillover	AD	9	*40.9%*	4	*18.2%*	14	*63.6%*	0	*0.0%*	22
g21	EM	12	*52.2%*	5	*21.7%*	12	*52.2%*	5	*21.7%*	23
	FR	11	*37.9%*	2	*6.9%*	14	*48.3%*	2	*6.9%*	29

Panel B: CGARCH

		Full-period				Post-Crisis				
		Pos		Neg		Pos		Neg		Total
RUS	AL	67	*90.5%*	0	*0.0%*	65	*87.8%*	1	*1.4%*	74
δ12	AD	21	*95.5%*	0	*0.0%*	21	*95.5%*	0	*0.0%*	22
	EM	23	*100.0%*	0	*0.0%*	23	*100.0%*	0	*0.0%*	23
	FR	23	*79.3%*	0	*0.0%*	21	*72.4%*	1	*3.4%*	29
Leverage	AL	49	*66.2%*	12	*16.2%*	43	*58.1%*	10	*13.5%*	74
γ	AD	20	*90.9%*	0	*0.0%*	18	*81.8%*	0	*0.0%*	22
	EM	16	*69.6%*	1	*4.3%*	15	*65.2%*	2	*8.7%*	23
	FR	13	*44.8%*	11	*37.9%*	10	*34.5%*	8	*27.6%*	29
Shock	AL	28	*37.8%*	26	*35.1%*	16	*21.6%*	38	*51.4%*	74
Spillover	AD	8	*36.4%*	9	*40.9%*	4	*18.2%*	10	*45.5%*	22
a21	EM	10	*43.5%*	7	*30.4%*	9	*39.1%*	11	*47.8%*	23
	FR	10	*34.5%*	10	*34.5%*	3	*10.3%*	17	*58.6%*	29
Asymmetric	AL	29	*39.2%*	23	*31.1%*	25	*33.8%*	24	*32.4%*	74
Shock	AD	13	*59.1%*	5	*22.7%*	10	*45.5%*	7	*31.8%*	22
Spillover	EM	6	*26.1%*	11	*47.8%*	6	*26.1%*	8	*34.8%*	23
d21	FR	10	*34.5%*	7	*24.1%*	9	*31.0%*	9	*31.0%*	29
Volatility	AL	39	*52.7%*	8	*10.8%*	30	*40.5%*	11	*14.9%*	74
Spillover	AD	10	*45.5%*	1	*4.5%*	11	*50.0%*	3	*13.6%*	22
g21	EM	13	*56.5%*	3	*13.0%*	10	*43.5%*	3	*13.0%*	23
	FR	16	*55.2%*	4	*13.8%*	9	*31.0%*	5	*17.2%*	29

Note: 'Pos' and 'Neg' shows a number of the markets with positive and negative estimates, respectively. % values indicate the percentage of the markets in the corresponding group that show the significance of corresponding parameters at 5% significance level, respectively.

Table 8. Asymmetry in volatility and spillovers and market development.

Panel A: Average market capitalisation (MC) and average trading volume (TR), % of GDP

	All	AD	EM	FR	All	AD	EM	FR
MC	69.10	118.14	60.47	32.04	74.57	132.44	65.97	33.18
TR	38.60	81.27	30.92	6.54	42.85	91.73	36.27	5.54

Panel B: Asymmetric volatility (γ or γ')

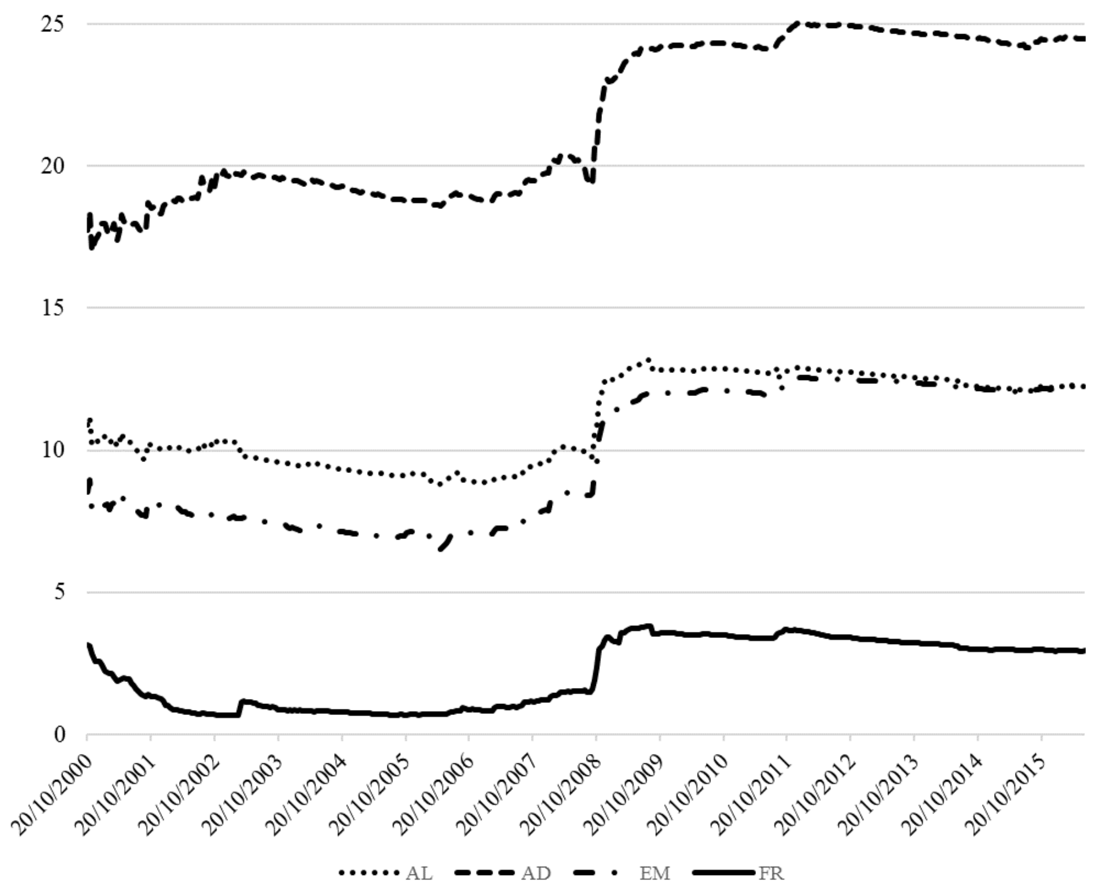
		Full				Post-crisis			
		All	AD	EM	FR	All	AD	EM	FR
EG	ξ_1(TR)	-0.0001	-0.0006 **	0.0010	0.0015	-0.0005 **	-0.0009 **	0.0002	0.0000
	ξ_2(MC)	0.0001	0.0004 **	0.0003	-0.0002	0.0002 *	0.0005 **	-0.0002 **	0.0007
CG	ξ_1(TR)	0.0007 *	0.0004	0.0000	0.0009	0.0004	0.0002	-0.0007	0.0055
	ξ_2(MC)	-0.0004	-0.0003	0.0001	-0.0020	-0.0003	-0.0003	-0.0001	-0.0029 **

Panel C: Asymmetric shock spillover (absolute value, d_{21})

		Full				Post-crisis			
		All	AD	EM	FR	All	AD	EM	FR
EG	ξ_1(TR)	0.0003	-0.0004	0.0000	-0.0023	0.0030 *	0.0003	0.0025 **	0.0007
	ξ_2(MC)	0.0001	0.0006	-0.0006	-0.0010	-0.0012	0.0003	-0.0015 *	-0.0023
CG	ξ_1(TR)	0.0001	0.0002	-0.0017	-0.0017	0.0013 **	-0.0024 *	0.0025 **	-0.0005
	ξ_2(MC)	-0.0003	-0.0001	-0.0024	-0.0005	-0.0004	0.0018 **	-0.0009 *	-0.0011

Note: EG and CG indicate whether the estimated parameters of asymmetric volatility and spillovers (AS), as dependent variables, are from the EGARCH or CGARCH models, respectively. ** and * indicate the statistical significance at 5% and 10% level, respectively.

Figure 1. The spillovers over time – the change in cross-variance shares



Note: this figure shows the change in the average of all cross-variance shares in the corresponding groups – all (AL), advanced (AD), emerging (EM) and frontier (FR) markets.

Appendix

Table A1. Asymmetry in volatility and spillovers - asymmetric full BEKK results, full sample

		EGARCH					CGARCH				
Group	Country	δ_{12}	γ	a_{21}	d_{21}	g_{21}	δ_{12}	γ	a_{21}	d_{21}	g_{21}
AD	Australia	0.3935 +	-0.0760 -	-0.0906 -	0.2232 +	-0.0186 -	0.4164 +	0.0704 +	-0.2590 -	0.1544 +	0.0175 +
	Austria	0.1802 +	-0.0833 -	0.0362 +	0.0876 +	-0.0052	0.1834 +	0.0995 +	-0.0357 -	0.0889 +	-0.0054
	Belgium	0.1321 +	-0.1104 -	0.3831 +	0.3113 +	0.8309 +	0.1435 +	0.0735 +	0.0035	-0.0754 -	-0.0021
	Canada	0.1138	-0.0843 -	-1.0908 -	-0.2452	3.3350 +	0.0860	0.1133 +	-0.2963 -	-0.2537 -	2.7288 +
	Denmark	0.2048 +	-0.0402 -	-0.0036	0.4181 +	0.4321	0.2057 +	0.0933 +	0.1568 +	0.1481 +	0.0265 +
	Finland	0.2698 +	-0.0539 -	0.0841 +	0.1799 +	-0.0216 -	0.2739 +	0.0817 +	-0.0920 -	-0.0595	0.0821 +
	France	0.2091 +	-0.1304 -	0.4209 +	-0.1409 -	0.2565 +	0.2300 +	0.0628 +	0.2616 +	0.1650 +	0.3309 +
	Germany	0.1565 +	-0.1124 -	0.0445 +	-0.0913 -	0.0037	0.1658 +	0.1129 +	-0.0448 -	0.0916 +	0.0034
	Hong Kong	0.4021 +	-0.0509 -	-0.2138	0.4459	0.5195 +	0.4072 +	0.0689 +	0.4889 +	-0.1480	0.4949
	Ireland	0.2018 +	-0.0700 -	-0.0817 -	0.0203	0.0231 +	0.2099 +	0.1086 +	0.0819 +	-0.0208	0.0233 +
	Israel	0.1189 +	-0.0246 -	0.1510 +	-0.0363	-0.0184 -	0.1265 +	0.0284	-0.1511 -	-0.0360	-0.0183 -
	Italy	0.1245 +	-0.1025 -	0.0282	-0.0373 -	-0.0006	0.1407 +	0.0774 +	0.0277	-0.0367 -	-0.0006
	Japan	0.4443 +	-0.0867 -	-0.1283 -	-0.1615 -	-0.0209 -	0.4446 +	0.0862 +	0.5986 +	0.2451 +	0.4118 +
	Netherlands	0.1349 +	-0.1159 -	-0.0152	-0.0637 -	0.0037	0.1594 +	0.1239 +	-0.0151	0.0637 +	0.0036
	New Zealand	0.2332 +	-0.0266 -	0.3659 +	-0.2407 -	0.8356 +	0.2348 +	0.0298	0.1506 +	0.1036 +	0.0034
	Norway	0.3732 +	-0.0837 -	-0.1403 -	0.1404 +	0.0200 +	0.3583 +	0.1265 +	0.3199 +	0.6306 +	0.5238 +
	Portugal	0.1267 +	-0.0834 -	0.0167	-0.0744 -	0.0001	0.1254 +	0.1736 +	-0.0170	0.0757 +	0.0000
	Singapore	0.2982 +	-0.0597 -	-0.0935 -	0.2361 +	-0.0071	0.3053 +	0.0701 +	-0.0905 -	0.2357 +	-0.0070
	Spain	0.1316 +	-0.1081 -	0.0659 +	-0.0739 -	-0.0026	0.1488 +	0.0960 +	0.0554 +	0.0754 +	-0.0020
	Sweden	0.2522 +	-0.0938 -	-0.0031	0.4394 +	-0.0043	0.2495 +	0.1215 +	-0.3102 -	-0.2020 -	0.0054
	Switzerland	0.0976 +	-0.1364 -	-0.0359	0.0742 +	0.0153 +	0.1330 +	0.1181 +	-0.0603 -	0.0780 +	0.0090 +
	UK	0.1897 +	-0.1228 -	-0.0184	-0.0856 -	0.0173 +	0.2083 +	0.1603 +	-0.0175	-0.0876 -	0.0169 +
EM	Brazil	0.0611 +	-0.0590 -	0.5552 +	-0.0704	0.3522 +	0.0508 +	0.0465	-0.0846 -	0.0355	0.0084
	Chile	0.0321 +	-0.0752 -	0.0036	0.0441 +	0.0096 +	0.0283 +	0.0962 +	0.0034	0.0454 +	0.0094 +
	China	0.5684 +	-0.0344 -	-0.7279 -	0.2323 +	0.3949 +	0.5684 +	0.1102 +	-0.4797 -	-0.4033 -	0.2732 +
	Colombia	0.0556 +	-0.0539 -	-0.0349 -	-0.0284	0.0041	0.0576 +	0.0843 +	-0.0350 -	-0.0287	0.0040
	Czech	0.2163 +	-0.0706 -	-0.4873 -	-0.0619	0.0806 +	0.2202 +	0.1321 +	0.4420 +	-0.2242 -	0.4349 +
	Egypt	0.2772 +	-0.0399 -	0.0115	0.3172 +	0.4434 +	0.2493 +	0.0578 +	0.4204 +	-0.4990 -	0.5069 +
	Greece	0.2370 +	-0.0387 -	0.0238	0.0306	0.5068 +	0.2242 +	0.0664 +	0.0290	-0.1338 -	-0.0162 -
	Hungary	0.2656 +	-0.0491 -	-0.2800 -	0.0467	0.0294 +	0.2483 +	0.1329 +	0.4409 +	-0.2617 -	0.3959 +
	India	0.2205 +	-0.0773 -	0.1243 +	-0.3476 -	-0.0100	0.2445 +	0.1427 +	-0.1237 -	0.3472 +	-0.0104
	Indonesia	0.4020 +	-0.0618 -	0.2024 +	-0.1731 -	-0.0187 -	0.3937 +	0.0590 +	0.1928 +	0.1680 +	-0.0162 -
	Korea	0.4603 +	-0.0439 -	-0.0089	0.1228 +	-0.0090	0.4648 +	0.0122	-0.0084	-0.1221 -	-0.0088
	Malaysia	0.2096 +	-0.0593 -	0.0693 +	0.0629 +	-0.0083 -	0.2139 +	-0.0087	0.0569 +	-0.0170	0.0134 +
	Mexico	-0.0318 -	-0.9196 -	0.8213	1.0801	0.5298	0.0494 +	0.0052	-0.6425	2.9910	1.2657
	Peru	0.0996 +	-0.0517 -	-0.0292	-0.0470	0.0547 +	0.1041 +	0.0451 +	-0.0241 -	-0.0145	0.0125 +
	Philippines	0.4060 +	-0.0354 -	0.2449 +	-0.2381 -	-0.0108	0.4366 +	-0.0716 -	0.3737 +	0.3436 +	0.3103 +
	Poland	0.2576 +	-0.0424 -	-0.6001 -	0.0438	0.3818 +	0.2713 +	0.0557 +	0.1415 +	-0.1784 -	-0.0072
	Qatar	0.2039 +	-0.0331 -	0.0284 +	-0.1326 -	-0.0211 -	0.1721 +	0.0751 +	-0.1766 -	-0.0475 -	0.1759 +
	Russia	0.3217 +	-0.0537 -	-0.0251	-0.3941 -	0.0333 +	0.3244 +	-0.0051	0.0488	-0.6378 -	0.5022 +
	S.Africa	0.2693 +	-0.0775 -	0.1914 +	-0.1751 -	0.0120 +	0.2985 +	0.1216 +	0.3666 +	-0.2097 -	0.2564 +
	Taiwan	0.4039 +	-0.0558 -	0.0532 +	-0.2477 -	-0.0106	0.3992 +	0.0883 +	-0.0124	0.0470 +	0.0071
	Thailand	0.3380 +	-0.0713 -	-0.4236 -	0.0230	0.4569 +	0.3376 +	0.0283	-0.3223 -	0.0136	0.3649 +
	Turkey	0.2410 +	-0.0405 -	-0.0609 -	0.1802 +	-0.0220 -	0.2479 +	0.0845 +	0.2982 +	0.1398 +	0.5170 +
	UAE	0.2947 +	-0.0622 -	0.2055 +	0.0682 +	-0.0276 -	0.2669 +	0.0977 +	0.1666 +	-0.2444 -	-0.0181 -
FR	Argentina	0.0490	-0.0450 -	-0.1633 -	0.2132 +	-0.0084	0.0672 +	0.0963 +	0.5856 +	0.0531	0.6189 +
	Bosnia & h	0.1225 +	-0.0996 -	0.0064	-0.0085	0.0965	0.0987 +	-0.1750 -	0.0402	-0.0567	0.4080 +
	Bahrain	0.0728 +	0.0063	-0.1728 -	0.1189 +	-0.0089	0.0587 +	-0.0731 -	-0.1728 -	-0.1191 -	-0.0089
	Bangladesh	0.0001	-0.0866 -	0.0052	-0.0105	0.0053	-0.0002	0.0569 +	-0.1842 -	0.1857 +	0.3302 +
	Botswana	0.0219	-0.0300 -	-0.0441 -	0.0896 +	-0.0088 -	0.0037 +	0.2449 +	0.0383 +	0.1380 +	0.0040
	Bulgaria	0.1005 +	0.0001	0.0218 +	0.0908 +	-0.0075	0.1009 +	-0.0242 -	-0.0305 -	-0.0782 -	-0.0027
	Croatia	0.1004 +	-0.0096 -	0.0263 +	-0.1104 -	-0.0155 -	0.1081 +	0.0265	0.0266 +	-0.1102 -	-0.0154 -
	Estonia	0.1816 +	0.0121 +	-0.0892 -	-0.0175	0.0185 +	0.1752 +	-0.1006 -	0.0851 +	0.1189 +	-0.0144 -
	Ghana	-0.1217 -	-0.1060 -	-0.0126	-0.4167 -	-0.0126	0.0052	0.2627 +	-0.0074	0.4180 +	-0.0120

Jamaica	0.0171 +	0.0384 +	-0.0200 -	-0.0022	0.0008	0.0125	-0.0839 -	-0.0200 -	-0.0025	0.0007
Jorden	0.0212 +	0.0339 +	0.0487 +	-0.0180	-0.0040	0.0247 +	-0.0673 -	0.0995 +	-0.1230 -	0.0453 +
Kazakhstan	0.4450 +	-0.0591 -	-0.0244	0.0192	0.0736 +	0.4471 +	0.0629	-0.0921 -	-0.0152	0.0740 +
Kenya	-0.0268 -	-0.0184 -	-0.4155 -	0.0469	0.0031	0.0155 +	-0.0615 -	-0.5838 -	-0.0624	0.7593 +
Lithuania	0.1294 +	-0.0437 -	-0.1145 -	0.1687 +	0.0390	0.1119 +	0.3789 +	0.1163 +	-0.1670 -	0.0396
Mauritius	0.0603 +	0.0229 +	0.1142 +	0.1043 +	0.0146 +	0.0359 +	0.0998 +	0.1144 +	0.1037 +	0.0148 +
Morocco	0.0340 +	-0.0183 -	0.0149	-0.0130	0.0088 +	0.0274 +	0.1086 +	-0.0147	-0.0136	0.0087 +
Nigeria	0.0447 +	0.1584 +	0.0895 +	-0.0293	0.4364 +	0.0172 +	0.3398 +	0.0315	0.1394 +	0.1460 +
Oman	0.0864 +	-0.0697 -	0.0437 +	0.1190 +	0.0187 +	0.0522 +	-0.2984 -	-0.1123 -	0.0030	0.0275 +
Pakistan	0.0422 +	-0.0689 -	0.0132	-0.0215	-0.0017	0.0548 +	0.0630 +	0.0133	0.0216	-0.0017
Palestine	0.0156	-0.0045	0.0132	0.0016	0.0081	0.0218	0.0508	-0.0132	-0.0015	0.0082
Romania	0.1454 +	0.0792 +	-0.4434 -	-0.2247 -	0.0785 +	0.1673 +	-0.0552 -	0.1886 +	0.0867 +	0.1004 +
Serbia	0.1480 +	-0.0346 -	0.1525	0.4040 +	0.4492	0.1320 +	0.0909 +	-0.1017 -	0.2595 +	-0.0260 -
Slovenia	0.1955 +	-0.0237 -	0.3109 +	0.3260 +	0.1114 +	0.1577 +	0.1717 +	0.0664 +	0.0796 +	-0.0078 -
Sri Lanka	0.0556 +	-0.0045	0.1997 +	0.0397	0.0238 +	0.0278 +	-0.0747 -	-0.0438 -	-0.0325 -	0.0159 +
Trinidad & T	0.0000	-0.6015 -	-0.1557 -	-0.0204	0.2746 +	0.0052	0.0361 +	0.2052 +	-0.0707 -	0.4227 +
Tunisia	0.0194 +	-0.0374 -	0.0601 +	-0.0070	0.0028	0.0174 +	-0.0331	-0.0490 -	0.0499 +	0.0040
Ukraine	0.1831 +	-0.2872 -	-0.1085	0.4686 +	0.4140	0.1966 +	0.0091	0.5049	-0.7576	0.8060 +
Vietnam	0.0971 +	-0.0043	-0.0734 -	0.0276	0.8474 +	0.0963 +	0.1151 +	-0.0233	0.0288	0.0145 +
Zimbabwe	0.1124 +	-0.0457	0.0554	0.0140	-0.0092	0.0549	-0.4916 -	0.0102	0.1292	0.1899 +

Note: + and – after the estimates indicate the significance at 5% level.

Table A2. Asymmetry in volatility and spillovers - asymmetric full BEKK results, post-crisis sub-sample

		EGARCH					CGARCH				
Group	Country	δ_{12}	γ	a_{21}	d_{21}	g_{21}	δ_{12}	γ	a_{21}	d_{21}	g_{21}
AD	Australia	0.5075 +	-0.0811 -	0.4524 +	-0.1707 -	0.0112	0.5444 +	0.1059 +	0.4574 +	0.1529 +	0.0128
	Austria	0.3071 +	-0.0928 -	-0.4968 -	-0.3372 -	0.4636 +	0.2962 +	0.1694 +	-0.1538 -	0.2381 +	0.0395 +
	Belgium	0.1469 +	-0.1233 -	0.1780	-0.4716 -	0.4107	0.1829 +	0.1253 +	-0.2903 -	0.1088 +	0.0143
	Canada	0.0936	-0.1113 -	1.3004 +	-3.1172 -	0.2522	0.0069	0.0655	-0.1221	0.2242 +	0.4898 +
	Denmark	0.1713 +	-0.0448 -	-0.2931 -	-0.0400	0.0392 +	0.1733 +	0.1349 +	-0.2932 -	0.0441	0.0394 +
	Finland	0.2198 +	-0.0856 -	-0.2794	-0.8646 -	0.4493	0.2368 +	0.0974 +	-0.1352 -	-0.2913 -	0.0356 +
	France	0.1863 +	-0.1607 -	0.0227	-0.1922 -	0.0283 +	0.2105 +	0.0831 +	0.0218	-0.1898 -	0.0286 +
	Germany	0.1439 +	-0.1248 -	0.3931 +	-0.4669 -	0.3145 +	0.1275 +	0.0892 +	0.0052	0.2106 +	0.0167
	Hong Kong	0.4454 +	-0.0590 -	-0.1986	-0.8048 -	0.4594	0.4662 +	-0.0300	-0.1994	-0.5165	0.6765
	Ireland	0.2244 +	-0.0641 -	0.5265 +	-0.2697	0.4625	0.2308 +	0.1199 +	0.1347 +	-0.3064 -	-0.0268 -
	Israel	0.1005 +	-0.0460 -	-0.4966 -	0.0802	0.4126 +	0.0957 +	0.0617 +	-0.1015 -	0.1553 +	-0.0348 -
	Italy	0.1672 +	-0.1200 -	-0.3134 -	-0.2917 -	0.3899 +	0.1622 +	0.1223 +	0.0359	-0.0714 -	0.0120
	Japan	0.5361 +	-0.0972 -	0.6066 +	0.2424 +	0.0405 +	0.5124 +	0.1303 +	-0.6843 -	-0.3176 -	0.2670 +
	Netherlands	0.1216 +	-0.1366 -	-0.4094 -	0.0484	0.9572 +	0.1722 +	0.1406 +	-0.2073 -	0.1874 +	0.0123
	New Zealand	0.2458 +	-0.0227 -	0.2116 +	0.2496 +	0.2443 +	0.2449 +	0.0526	-0.1792 -	0.0821 +	0.0040
	Norway	0.4380 +	-0.0978 -	0.4509 +	0.4176 +	0.4287 +	0.4712 +	0.0561	-0.5062 -	0.2386 +	0.1176 +
	Portugal	0.1080 +	-0.1204 -	0.0149	-0.1556 -	0.0042	0.1197 +	0.1949 +	0.0150	-0.1553 -	0.0042
	Singapore	0.2992 +	-0.0759 -	0.1977 +	0.2577 +	0.1451 +	0.3188 +	0.1009 +	0.1795	-0.7027 -	0.4286 +
	Spain	0.0955 +	-0.1264 -	0.0975 +	-0.0948 -	-0.0001	0.1347 +	0.1186 +	-0.2040	-0.0145	0.4572 +
	Sweden	0.2145 +	-0.1002 -	-0.3518 -	-0.3162 -	0.4121 +	0.2328 +	0.0854 +	0.2900 +	0.0026	-0.0186 -
	Switzerland	0.1317 +	-0.1397 -	0.2246 +	-0.2757 -	0.0418 +	0.1828 +	0.0793 +	-0.2229 -	0.0890 +	0.0160 +
	UK	0.2324 +	-0.1311 -	0.3464 +	-0.1108 -	0.0593 +	0.2579 +	0.1165 +	0.3481 +	0.1026	0.0600 +
EM	Brazil	0.1295 +	-0.0658 -	-0.3531 -	-0.3195 -	0.5536 +	0.1226 +	0.1058 +	-0.0246	-0.0434	0.3047 +
	Chile	0.0690 +	-0.0910 -	0.0177	-0.0606 -	0.0117 +	0.1017 +	0.1056 +	0.0170	0.0613 +	0.0111 +
	China	0.6241 +	-0.0443 -	-0.5651 -	-0.7148 -	0.1825 +	0.6034 +	0.0608 +	-0.1015	-0.4538 -	0.5252 +
	Colombia	0.1053 +	-0.0930 -	0.1919 +	0.0224	0.0222 +	0.0991 +	0.1333 +	-0.1921 -	-0.0214	0.0221 +
	Czech Rep.	0.1868 +	-0.0789 -	0.5575 +	-0.2500 -	0.7143 +	0.1740 +	0.1314 +	0.3545 +	-0.1047 -	0.0646 +
	Egypt	0.3209 +	-0.0913 -	-0.6514 -	-0.2731 -	0.1176 +	0.3568 +	0.1283 +	-0.1466 -	0.0842 +	0.0824 +
	Greece	0.2448 +	-0.0505 -	0.1367	0.0590	0.4483	0.2393 +	-0.0103	0.2925 +	-0.2295 -	-0.0009
	Hungary	0.1998 +	-0.0665 -	-0.1961	-0.5113	0.5906	0.1754 +	0.1776 +	0.3209 +	0.0135	0.0165
	India	0.2455 +	-0.0667 -	-0.4240 -	-0.3813 -	0.5099 +	0.2762 +	0.0812 +	-0.2818 -	0.3250 +	-0.0038
	Indonesia	0.4583 +	-0.0803 -	-0.3121 -	-0.2214 -	0.1052 +	0.4677 +	0.0769	-0.1568 -	-0.1653 -	0.0322 +
	Korea	0.3947 +	-0.0732 -	-0.2449 -	0.2066 +	-0.0613 -	0.4280 +	-0.1249 -	0.0906 +	0.2302 +	-0.0256 -
	Malaysia	0.2183 +	-0.0811 -	0.0839 +	-0.1018 -	-0.0118 -	0.2302 +	-0.0348	0.0536 +	0.0000	0.0198 +
	Mexico	0.0110	-0.0792 -	-0.2056 -	-0.0521	-0.0146 -	0.0453 +	-0.0610	-0.2050 -	0.0520	-0.0139 -
	Peru	0.0785 +	-0.0685 -	-0.0423 -	-0.0500	0.0119	0.0997 +	0.1390 +	0.0442 +	-0.0455	0.0122
	Philippines	0.4068 +	-0.0585 -	-0.3457 -	0.5002 +	0.2227 +	0.4202 +	0.0587	-0.2646 -	-0.0270	-0.0097
	Poland	0.1947 +	-0.0873 -	-0.2127 -	-0.1945 -	0.0024	0.2015 +	0.1957 +	-0.2128 -	0.1929 +	0.0022
	Qatar	0.2181 +	-0.0389 -	-0.0329 -	-0.1319 -	-0.0178 -	0.2121 +	-0.0957 -	0.1489 +	-0.0305	0.0640 +
	Russia	0.3404 +	-0.0888 -	-0.0862	-0.4971 -	0.0459 +	0.3418 +	0.0357	-0.1768 -	-0.3482 -	0.5022 +
	S.Africa	0.2529 +	-0.1295 -	-0.2349 -	-0.1084 -	0.0040	0.2947 +	0.1180 +	-0.2191 -	0.1624 +	0.0088
	Taiwan	0.4170 +	-0.0678 -	-0.2639 -	-0.2434 -	-0.0503 -	0.4139 +	0.1086 +	0.3432 +	0.0187	-0.0024
	Thailand	0.3793 +	-0.0780 -	-0.6107 -	-0.2529 -	0.3359 +	0.3437 +	0.1394 +	-0.1210 -	-0.2580 -	0.0131
	Turkey	0.1679 +	-0.0751 -	-0.5082 -	-0.1210	0.4361 +	0.1601 +	0.1233 +	0.1277 +	-0.3084 -	-0.0266 -
	UAE	0.3430 +	-0.0711 -	-0.2854 -	0.2900 +	0.0017	0.3231 +	0.1165 +	-0.2854 -	-0.2924 -	0.0024
FR	Argentina	0.0900 +	-0.0863 -	-0.1781 -	-0.4901 -	0.0227	0.0697	0.1395 +	0.1781 +	0.4908 +	0.0227
	Bosnia & h	0.1225 +	-0.0996 -	0.0064	-0.0085	0.0965	0.0987 +	-0.1750 -	-0.0012	0.0145	0.0160
	Bahrain	0.0482 +	-0.0352 -	0.0992 +	-0.1119 -	-0.0068	-0.0010	-0.0984 -	-0.1009 -	0.1111 +	-0.0054
	Bangladesh	0.0081	-0.1423 -	-0.0101	0.0443	0.0390 +	0.0165	-0.0281	-0.0449 -	-0.0420 -	0.0013
	Botswana	0.0219	-0.0300 -	-0.0441 -	0.0896 +	-0.0088 -	0.0037 +	0.2449 +	-0.0179	0.1267 +	-0.0201 -
	Bulgaria	0.1325 +	-0.0429 -	-0.3363 -	-0.3579 -	0.2236 +	0.1129 +	0.1626 +	-0.1143 -	0.1114 +	0.0023
	Croatia	0.1214 +	-0.0466 -	0.0295	0.1325 +	-0.0224 -	0.1244 +	-0.0135 -	0.0309	-0.1292 -	-0.0221 -
	Estonia	0.2358 +	-0.0148 -	0.3506 +	0.0470	0.5987 +	0.1992 +	-0.0312	-0.1041	0.1508	0.6595 +
	Ghana	-0.1217 -	-0.1060 -	-0.0126	-0.4167 -	-0.0126	0.0052	0.2626 +	0.0121	0.4241 +	0.0020
	Jamaica	0.0148	0.0297 +	0.0235 +	0.0081	0.0031	0.0141	-0.0348	-0.0235 -	0.0078	0.0030

Jorden	0.0933 +	0.0482 +	-0.1479 -	0.0678 +	0.0272 +	0.0686 +	-0.0368	-0.1483 -	0.0644 +	0.0264 +
Kazakhstan	0.4409 +	-0.0688 -	0.1381	0.4815 +	0.4527 +	0.4284 +	-0.0370	-0.1749 -	0.0523	0.1133 +
Kenya	0.0357 +	-0.0111	0.0724 +	-0.0324 -	0.0128 +	0.0216 +	-0.1060 -	-0.0725 -	-0.0313 -	0.0123 +
Lithuania	0.1294 +	-0.0437 -	-0.1145 -	0.1687 +	0.0390	0.1119 +	0.3789 +	-0.1163 -	-0.1670 -	0.0396
Mauritius	0.0590 +	-0.0181 -	-0.1670 -	-0.1556 -	0.4902 +	0.0488 +	-0.0344	-0.0983 -	-0.0142	0.0017
Morocco	0.0479 +	-0.0334 -	-0.2097 -	0.0500	0.3119 +	0.0504 +	0.0968 +	0.1007 +	-0.1434 -	-0.0233 -
Nigeria	0.0330 +	0.0060	0.0436 +	0.0373	-0.0071	0.0351 +	0.0093	-0.0439 -	0.0189	-0.0036
Oman	0.1151 +	-0.0496 -	-0.0791 -	0.1410 +	-0.0060	0.0814 +	-0.1025 -	0.0847 +	-0.1311 -	-0.0031
Pakistan	0.0295 +	-0.1211 -	-0.1989	-0.2106	0.3823	0.0192 +	0.1963 +	-0.0073	0.0094	0.0047
Palestine	0.0156	-0.0045	0.0132	0.0016	0.0081	0.0218	0.0508	-0.0132	-0.0015	0.0082
Romania	0.1046 +	0.1083 +	-0.2065 -	0.0504	0.1195 +	0.1529 +	-0.0855 -	-0.2058 -	-0.0515	0.1194 +
Serbia	0.1480 +	-0.0346 -	0.1525	0.4040 +	0.4492	0.1320 +	0.0909 +	-0.1017 -	0.2595 +	-0.0260 -
Slovenia	0.1697 +	-0.0769 -	0.2253 +	0.1645 +	0.0690 +	0.1674 +	0.0096	-0.2248 -	0.1675 +	0.0693 +
Sri Lanka	0.0119	-0.0220 -	-0.3420 -	-0.5238 -	0.4572 +	0.0188 +	-0.0334	-0.0306 -	-0.3081 -	-0.0180 -
Trinidad & T	-0.0085	-0.2694 -	-0.0694 -	0.0814 +	0.0384 +	-0.0238 -	-0.1570 -	-0.1443 -	-0.1294 -	0.3779 +
Tunisia	0.0315 +	-0.0660 -	-0.1430	-0.1495	0.4568	0.0257 +	0.0940 +	-0.0072	0.0496 +	0.0138
Ukraine	0.1934 +	-0.0263 -	-0.1130 -	0.0074	0.0229 +	0.2024 +	0.0637 +	-0.1137 -	-0.0077	0.0231 +
Vietnam	0.2328 +	-0.0493 -	0.0575 +	-0.0856 -	0.0294 +	0.2162 +	0.0780	-0.0566 -	-0.0852 -	0.0292 +
Zimbabwe	0.1124 +	-0.0457	0.0554	0.0140	-0.0092	0.0579	-0.5414 -	0.0566	-0.0205	-0.0119

Note: + and – after the estimates indicate the significance at 5% level.