

Pätäri, Eero; Ahmed, Sheraz; John, Elena; Karell, Ville

Article

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*Corresponding author: Eero Pätäri,
School of Business and Management,
LUT University, Lappeenranta, Finland
E-mail: eero.patari@lut.fi

Reviewing editor:
David McMillan, University of Stirling,
Stirling, UK

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

The changing role of emerging and frontier markets in global portfolio diversification

Eero Pätäri^{1*}, Sheraz Ahmed¹, Elena John¹ and Ville Karell¹

Abstract: Although the literature on the benefits of diversifying equity portfolios to emerging markets is abundant, the role of frontier markets in global equity portfolio diversification is clearly less examined. We contribute to the existing literature by examining three different, though closely related, spillover effects (i.e., return, shock and volatility spillovers) between developed, emerging and frontier markets over the period from June 2002 to December 2016. We also investigate the time-variability in the cross-market correlations within the same period. Moreover, we divide the full-sample period into two sub-periods to find out how the intensity of integration of emerging and frontier markets with three developed equity markets (represented by the US, European and Japanese stock markets) has changed or varied during the sample period. Based on both correlation analysis and the VAR(1)–BEKK–GARCH(1,1) model, the global financial crisis and the Euro-zone crisis 2009–2012 have changed the interlinkages between developed and developing markets, as well as those between emerging and frontier markets. The results show that after the global financial crisis, particularly frontier markets have become more integrated with the developed markets, whereas in case of emerging markets, the same tendency has taken place already

ABOUT THE AUTHOR

Eero Pätäri (corresponding author) is a Full Professor of Finance in the School of Business and Management at LUT University, Finland. His research activities have so far been focused on risk and performance measurement of active equity investment strategies, mutual funds and hedge funds, with the recent emphasis on direct equity investments. In the related publications, he has developed several complementary risk and performance measures, thereby aiming to contribute to the so-called post-modern portfolio theory. He has also innovated cross-disciplinary stock-selection methodologies, by means of which it is possible to merge many dimensional stock selection criteria into a single criterion. In his previous journal publications, he has examined many national stock markets, including the U.S., German, Finnish and Russian markets. In addition, he has written extensive literature review articles on value premium and mutual fund performance persistence. Altogether, he has published over 20 research papers in internationally-acknowledged journals.

PUBLIC INTEREST STATEMENT

This paper examines the role of emerging and frontier markets in the global equity portfolio diversification. The primary goal of global portfolio diversification is to lower the non-diversifiable market risk by exploiting low correlations among national stock markets and/or among different asset classes. However, the increased economic integration tends to increase cross-market correlations, thereby reducing the benefits of international diversification. This tendency has driven investors to seek diversification benefits from emerging and frontier markets that, among all equity markets, have historically correlated least with the developed stock markets. Our overall results show that during the 21st century, both emerging and frontier markets have started to integrate more with the developed stock markets to the extent that the benefits of diversifying to these two developing markets—at least via broad market capitalization-weighted indices—have clearly decreased. The increased overall cross-market integration has important practical implications for the risk management of global equity portfolios.

before the financial crisis. The increased cross-market integration has important practical implications for risk management of global equity portfolios.

Subjects: Financial Mathematics; Economics; Finance

Keywords: risk management; international diversification; spillover; bi-variate VAR; BEKK-GARCH; financial crisis; drawdown; crash risk; global equity portfolio; global diversification

Subjects: G01; G11; G15

1. Introduction

The primary goal of global portfolio diversification is to exploit low correlations among national stock markets and/or among different asset classes. However, the increased economic and financial integration have led to elevated correlations among markets, thereby reducing the benefits of international diversification (see, e.g. Baele & Inghelbrecht, 2009; Bekaert & Harvey, 2000; Brooks & Del Negro, 2004; Driessen & Laeven, 2007; Errunza, Hogan, & Hung, 1999; Goetzmann, Li, & Rouwenhorst, 2005; Kizys & Pierdzioch, 2009; Longin & Solnik, 1995). International equity markets tend to have increased co-movements during stock market turbulence even in cases where macroeconomic fundamentals do not indicate strong interdependence (see, e.g. King, Sentana, & Wadhwani, 1994; Longin & Solnik, 1995, 2001; Santis & Gerard, 1997; Chesnay & Jondeau, 2001). This tendency has driven investors to seek diversification benefits from emerging and frontier markets.

A large number of earlier studies have presented evidence that emerging stock markets strongly co-move with the developed stock markets. On the other hand, few studies have shown that the sensitivity of emerging markets to global financial shocks has decreased over the past two decades. For example, Ammer, Cai, and Scotti (2011) find that during the financial crisis 2007–2009, the vulnerability of emerging markets to external shocks was moderate in comparison with historical exposure due to continuous improvements in the underlying fundamentals. A similar pattern of volatility spillovers from developed to emerging financial markets is also detected by Hacıhasanoglu, Simga-Mugan, and Soytaş (2012), who show that such spillovers were strong before the recent global financial crisis, declined during the crisis, and somewhat resurged in the post-crisis recovery period. By contrast, Dooley and Hutchison (2009) find that emerging markets were decoupled from price shocks originated in the U.S. equity market prior to the recent crisis, but these linkages re-emerged during the late summer of 2008.¹ On the other hand, Valls and Chuliá (2012) conclude that after the crisis, volatility transmission between the U.S. and the Asian emerging and frontier markets has remained pretty much at the same level as during the crisis. Even after taking account of methodological differences of the above-cited studies, overall evidence on the relative intensity of spillover effects in emerging and frontier markets is somewhat mixed. This may also be partially explained by the findings of Bekaert, Ehrmann, Fratzscher, and Mehl (2014) who report outstanding regional differences in the spillover exposures between the Eastern European, Asian, Middle East/African, and Latin American emerging markets particularly, when an underlying shock was of U.S. origin. Moreover, Ahmad, Sehgal, and Bhanumurthy (2013) report that the interlinkages of GIPSI (i.e. Greek, Irish, Portuguese, Spanish and Italian), US, UK, and Japanese stock markets were different to the stock markets of BRICS countries, compared to those of Indonesia and South Korea.

While the literature on potential diversification benefits from the emerging markets is abundant, the role of frontier markets in global equity portfolio diversification is clearly less examined. We contribute to the existing literature by comparing the strength of the three different, yet closely related, spillover effects (i.e., return, shock and volatility) between developed, emerging and frontier markets over the period from June 2002 to December 2016. We further divide the full-sample period into two sub-periods (before and after 1 January 2008)² to find out whether the global financial crisis

and the Euro-zone crisis 2009–2012 have changed these spillover relationships between developed and developing markets, as well as between emerging and frontier markets.

The majority of the previous spillover studies has concentrated on one national or group of few regional markets as emerging or frontier markets (e.g., see Hatipoglu & Uyar, 2012; Kim, Kim, & Kim, 2010; Kim, Kim, & Lee, 2015; Kim & Ryu, 2015; Li & Zhang, 2013; Valls & Chuliá, 2012), whereas in this study we treat these two markets as separate equity classes and analyze their aggregate behavior, similar to Hacıhasanoglu et al. (2012) and Badshah (2018).³ We find evidence that both the intensity and direction of return and volatility spillovers have varied between emerging and frontier markets across the two sub-periods. Our results also confirm that while the integration of emerging markets with developed markets started earlier, the same tendency did not occur in the case of frontier markets until the period of the financial crisis. The role of frontier markets as a standalone equity class has increased both in terms of shock and volatility transmission after the financial crisis and their interlinkages are tighter with the developed European markets than with the US markets. Consequently, the role of the two types of developing markets in the global equity portfolio diversification has changed during the 14 and ½-year sample period.

This remainder of the paper is organized as follows: Methodology and data are described in sections 2 and 3. Section 4 introduces the empirical results, whereas section 5 concludes with a discussion on practical implications.

2. Methodology

In order to explore the relationship between two or more markets, the multivariate specification of GARCH is employed. Engle and Kroner (1995) proposed the BEKK (abbreviation from Baba, Engle, Kraft, & Kroner, 1989) parameterization, which allows to exhibit the direction of impact between two different markets when other markets and their conditions are not considered to affect that specific pair of markets. Thus, a bivariate representation is adopted in order to analyze the interdependences of emerging markets (EM) and frontier markets (FM) with the developed equity markets. The conditional mean returns of the pairwise markets are estimated on the basis of the bivariate vector autoregressive of order one (i.e. VAR (1)) model, in line with Bekiros (2014) as follows:

$$\begin{aligned} y_{1t} &= \mu_1 + \beta_{11}y_{1t-1} + \beta_{12}y_{2t-1} + u_{1t}, \\ y_{2t} &= \mu_2 + \beta_{21}y_{1t-1} + \beta_{22}y_{2t-1} + u_{2t}, \end{aligned} \quad (1)$$

where u_{it} is an error term with $E(u_{it}) = 0$ and $\sigma^2(u_{it}) = 1$. Hence, each y_{it} depends on immediately previous values of both variables y_{1t-1} and y_{2t-1} , and the corresponding error term.

Following Karolyi (1995) and Caporale, Pittis, and Spagnolo (2006), the shock and volatility linkages between each pairwise market are estimated on the basis of the bivariate BEKK-GARCH (1,1) model,⁴ which can be stated as:

$$H_t = C_0 C_0' + A_{11} \varepsilon_{t-1} \varepsilon_{t-1}' A_{11}' + G_{11} H_{t-1} G_{11}', \quad (2)$$

where C_0 is a 2×2 lower triangular matrix and A_{11} and G_{11} are 2×2 matrices. The A_{11} matrix elements capture the effects of shocks (ARCH effects), whereas the G_{11} matrix elements capture the information of past volatility effects (GARCH effect). In addition, the diagonal elements in matrices A_{11} and G_{11} capture their own ARCH and GARCH effects, respectively. Moreover, the off-diagonal elements of A_{11} capture the shock transmissions between the markets, whereas the off-diagonal elements of G_{11} capture the volatility spillovers between the markets (see, e.g., Bauwens, Laurent, & Rombouts, 2006; Tsay, 2005). The BEKK-GARCH (1,1) with individual elements can be written as:

$$\begin{aligned} H_t &= C_0 C_0' + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t-1}^2 & \varepsilon_{1t-1} \varepsilon_{2t-1} \\ \varepsilon_{2t-1} \varepsilon_{1t-1} & \varepsilon_{2t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \\ &\quad + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} H_{t-1} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \end{aligned} \quad (3)$$

Each element of the BEKK model can be further expanded by matrix multiplication as follows:

$$h_{11t} = c_{11}^2 + a_{11}^2 \varepsilon_{1t-1}^2 + 2a_{11}a_{21}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}^2 \varepsilon_{2t-1}^2 + g_{11}^2 h_{11t-1} + 2g_{11}g_{21}h_{12t-1} + g_{21}^2 h_{22t-1} \quad (4)$$

$$h_{12t} = c_{11}c_{21} + a_{11}a_{12}\varepsilon_{1t-1}^2 + (a_{21}a_{12} + a_{11}a_{22})\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}a_{22}\varepsilon_{2t-1}^2 + g_{11}g_{12}h_{11t-1} + (g_{21}g_{12} + g_{11}g_{22})h_{12t-1} + g_{21}g_{22}h_{22t-1} \quad (5)$$

$$h_{22t} = c_{21}^2 + c_{22}^2 + a_{12}^2 \varepsilon_{1t-1}^2 + 2a_{12}a_{22}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{22}^2 \varepsilon_{2t-1}^2 + g_{12}^2 h_{11t-1} + 2g_{12}g_{22}h_{12t-1} + g_{22}^2 h_{22t-1} \quad (6)$$

In order to test for a causality effect between the markets, the specific off-diagonal elements of matrices \mathbf{A}_{11} and \mathbf{G}_{11} must be set equal to zero. For instance, a causality effect from the first market to the second market can be tested by setting a_{12} and g_{12} to zero. In this case, Equations (4)–(6) can be presented as follows:

$$h_{11t} = c_{11}^2 + a_{11}^2 \varepsilon_{1t-1}^2 + 2a_{11}a_{21}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}^2 \varepsilon_{2t-1}^2 + g_{11}^2 h_{11t-1} + 2g_{11}g_{21}h_{12t-1} + g_{21}^2 h_{22t-1} \quad (7)$$

$$h_{12t} = c_{11}c_{21} + a_{11}a_{22}\varepsilon_{1t-1}\varepsilon_{2t-1} + a_{21}a_{22}\varepsilon_{2t-1}^2 + g_{11}g_{22}h_{12t-1} + g_{21}g_{22}h_{22t-1}$$

$$h_{22t} = c_{21}^2 + c_{22}^2 + a_{22}^2 \varepsilon_{2t-1}^2 + g_{22}^2 h_{22t-1}.$$

Correspondingly, h_{21t} can be derived analogously to h_{12t} , in which case a_{21} and g_{21} must be set to zero to test causality effects from the second market to the first market. Following Engle and Kroner (1995), the above Equation (7) can be estimated by the maximum likelihood function which can be optimized by applying the Berndt, Hall, Hall, and Hausman (1974) algorithm. From the equations we obtain the conditional log-likelihood function $L(\theta)$ for a sample of T observations:

$$L(\theta) = \sum_{t=1}^T l_t(\theta), \quad (8)$$

$$l(\theta) = -\log 2\pi - 1/2 \log |\mathbf{H}_t(\theta)| - 1/2 \varepsilon_t'(\theta) \mathbf{H}_t^{-1}(\theta) \varepsilon_t(\theta), \quad (9)$$

where θ denotes the vector of all the unknown parameters. Numerical maximization of Equation (9) yields the maximum likelihood estimates with asymptotic standard errors.

Finally, to test the null hypothesis that the model is correctly specified, or that the estimated residuals are independently distributed (i.e. have no autocorrelation), the Ljung and Box (1978) Q -test is used. Under the null hypothesis (H_0), the Q -statistic at lag k asymptotically follows a chi-squared ($\chi_{(h)}^2$) distribution with h degrees of freedom, where h is the total number of lags being tested (In this paper, h is set to 26). The rejection of randomness hypothesis implies that $Q_k > \chi_{1-\alpha, h}^2$ outside of the confidence interval α .

3. Data

The data consist of Morgan-Stanley Composite Indices (MSCI total return indices) for emerging markets (EM), frontier markets (FM), Japan, and the European developed markets (DE). Following Dooley and Hutchison (2009), Moon and Yu (2010) and Berger, Pukthuanthong, and Yang (2013), among others, we use the S&P 500 total return index as the proxy for the U.S. market return. The sample period extends from June 2002 to December 2016, starting from the time point from which the calculation of the MSCI FM index was initiated.⁵ Weekly closing quotes (in US dollars) are downloaded from Datastream, and the corresponding returns are calculated based on the Thursday's closing quotes. The weekly prices are employed because of the trading-hour differences between geographically distant stock markets included in the sample (e.g., see Boyer, Kumagai, & Yuan, 2006; Ng, 2000; Saleem & Vaihekoski, 2010).

Descriptive statistics for the full sample period are shown in Table 1 (Panel A). The highest average return (6.86% p.a.), as well as the highest volatility (21.70% p.a.) is documented for EM. Interestingly, FM have been the least volatile markets with a surprisingly low standard deviation of

Table 1. Descriptive statistics of stock return indices

	US	DE	Japan	EM	FM
<i>Panel A: Descriptive statistics for the full sample period (Jan 2002—Dec 2016)</i>					
Annualized Mean (%)	6.01	4.11	4.15	6.86	6.36
Minimum (%)	−20.20	−14.79	−12.32	−20.21	−14.63
Maximum (%)	16.61	11.35	14.44	12.31	8.00
SD (%)	17.36	20.79	19.05	21.70	14.79
SKASD (%)	29.86	25.71	20.73	28.06	22.42
Skewness	−1.32	−0.63	−0.09	−0.80	−1.51
Excess kurtosis	15.11	3.24	1.87	4.20	9.12
Maximum drawdown (%)	−55.25	−63.11	−53.04	−65.34	−67.43
J-B test statistic	7949.49***	385.74***	113.72***	643.69***	2940.77***
<i>Panel B: Descriptive statistics of the first sub-period (Jan 2002—Dec 2007)</i>					
Annualized Mean (%)	7.71	16.35	8.81	26.80	28.69
Minimum (%)	−5.05	−9.49	−9.11	−12.23	−6.50
Maximum (%)	8.96	9.51	9.48	7.77	6.36
SD (%)	13.09	15.71	19.33	18.60	12.18
SKASD (%)	14.17	19.66	20.60	23.20	12.86
Skewness	−0.05	−0.76	−0.22	−0.99	−0.08
Excess kurtosis	2.17	3.36	0.53	2.45	1.19
J-B test statistic	58.68***	167.68***	6.18**	122.57***	18.25***
<i>Panel C: Descriptive statistics of the second sub-period (Jan 2008—Dec 2016)</i>					
Annualized Mean (%)	4.98	−2.79	1.37	−3.85	−5.44
Minimum (%)	−20.20	−14.79	−12.32	−20.21	−14.63
Maximum (%)	16.61	11.35	14.44	12.31	8.00
SD (%)	19.54	23.33	18.87	23.29	15.99
SKASD (%)	33.35	27.83	20.77	29.80	24.53
Skewness	−1.48	−0.52	−0.01	−0.66	−1.78
Excess kurtosis	14.56	2.48	2.78	4.29	9.65
J-B test statistic	4367.21***	143.41***	154.28***	401.07***	2094.16***

For the full sample period from June 2002 to December 2016, Panel A shows descriptive statistics for the five equity markets examined, represented by the MSCI indices for the developed European (DE) markets, Japanese markets, emerging markets (EM), and frontier markets (FM), and by the S&P 500 index for the US market. For each market, annualized geometric average return, minimum and maximum weekly return, annualized standard deviation (SD), skewness- and kurtosis-adjusted standard deviation (SKASD), Fisher's skewness, excess kurtosis, maximum drawdown, and the Jarque-Bera (JB) test statistic are reported, for which the significances at the 1%, 5%, and 10% level are indicated by ***, **, and *, respectively (All the statistics are calculated on the basis of weekly index total returns). Panel B (C) shows the corresponding statistics for the first (second) sub-periods, with the exception that for validity reasons, maximum drawdowns are not reported for the sub-periods.

only 14.79% p.a. In light of the fact that FM has simultaneously generated the second-highest return (i.e., 6.36% p.a.), the return-to-risk ratio has been particularly attractive for FM. However, there are huge differences between the two sub-periods across the markets to the extent that the attractiveness of FM is fully based on its performance during the first sub-period. During the first 5 and ½-year sub-period, the average annualized return for FM was as high as 28.69% (Panel B), whereas during the latter, it was the lowest among the five equity markets being compared, only—5.44% p.a (Panel C). By contrast, the U.S. stock market, which generated the lowest return during the first sub-period, was the best in terms of returns during the second with an average annual return of 4.98%.

All the weekly return time-series are negatively skewed and leptokurtic so that the Jarque and Bera (1980) test rejects the null of normally distributed return in all the cases of the full-period time-series at the 1% significance level. The same also holds for both sub-periods, except in the case of the Japanese market during the first sub-period, where the corresponding null hypothesis is rejected at the 5% significance level. Because of systematic violation of the normality assumption of the return distributions examined, we also calculate the skewness- and kurtosis-adjusted standard deviation (SKASD) for each market, in line with Pätäri (2011).⁶ Because of strong leptokurtosis and negative skewness in its full sample period returns, particularly the US market turns out to be far riskier in terms of the SKASD than it looks based on simple volatility. The corresponding difference between SKASD and volatility is even larger during the second sub-period, when the annualized SKASD of the U.S. markets has been as high as 33.35%. A similar relationship also holds for the other examined markets, although the differences between SKASD and volatility are clearly smallest in the Japanese market during both the full sample period and the second sub-period. By contrast, during the first sub-period, the differences between SKASDs and volatilities are relatively small in all the examined markets.

Nevertheless, in terms of return-to-risk ratios, the skewness- and kurtosis-adjustment do not radically change the relative performance order of the examined markets, as FM remains the most attractive market during the first sub-period, as well as during the full sample period. Similarly, the U.S. market stays the best-performing one among the five examined markets during the second sub-period in spite of the fact that its SKADS is radically higher than its volatility.

Panel A in Table 1 also shows maximum drawdown (MDD) statistics for the five equity markets examined. Similar to Rujeerapaiboon, Kuhn, and Wiesemann (2016), MDD is defined as the maximum percentage loss over any subinterval of the full sample period. For all five markets, MDDs have realized during the financial crisis. Expectedly, the greatest MDD of—67.43% is documented for FM, followed by EM with—65.34%, thereby indicating that MDD clearly represents another dimension of portfolio risk than the volatility and/or SKASD. Interestingly, the period during which an index crashed from its pre-crisis peak value to the following trough, was shorter in developing markets than in developed markets⁷. For EM, the time span from the pre-crisis peak to the following trough was less than 1 year, as the corresponding peak was reached on 31 October 2007 and the subsequent trough was documented already on October 27 next year. In the four other markets, the decline continued until March 2009, being the longest in the Japanese markets, where the falling tendency started already in May 2006. By contrast, in FM, the pre-crisis peak was not reached until 15 January 2008. Among the examined five markets, the MDD was smallest in the Japanese markets (–53.04%), while being highest in FM and EM, where the drawdown periods were shortest, thereby supporting earlier findings, according to which stock market crashes are generally steeper and faster in developing markets than in developed markets (e.g., see Patel & Sarkar, 1998). Among the same five equity markets, the U.S. markets were the first to recover from the crash caused by the financial crisis, as the S&P 500 total return index exceeded first its pre-crisis peak value in May 2013. In Japan, the pre-crisis peak was exceeded in March 2015, whereas in DE, EM and FM, the same did not happen during our sample period.

4. Results

In order to discern possible changes in the long-term interactions of emerging and frontier markets with developed markets, we divide the full-length sample period into two sub-periods. The first, representing a moderate and stable period in the world economy, begins in June 2002 and ends in December 2007, whereas the second sub-period runs from January 2008 until December 2016. The latter period can be characterized by a highly volatile market condition originating from the sub-prime crisis and liquidity shortfall in the US, which undermined financial performance in Europe leading to a sovereign debt crisis. The analysis on stock markets' interrelations in sub-periods aims to reveal whether the latest financial crisis affected these relations, which are particularly relevant from the viewpoint of international equity portfolio diversification.

4.1. The sub-period cross-market correlations

Table 2 summarizes the return correlation across the markets during the first sub-period from June 2002 to Dec 2007.⁸ During this 5 and ½-year period, all cross-market correlations between the U.S., Japanese, DE and emerging markets are highly significant, although there are remarkable differences in the levels of correlation coefficients. Interestingly, the return correlation of the Japanese markets with DE and the U.S. markets have been surprisingly low, though still highly significant, to the extent that the Japanese markets have correlated more with EM than with the two other developed markets. On the other hand, EM have correlated surprisingly strongly with the U.S. markets, and particularly, with DE to the extent that the highest pairwise correlation is documented between EM and DE. By contrast, the correlation of FM with the U.S. and Japanese markets has not been significant at all, whereas with DE, it has been only weakly significant (at the 10% level). The only strongly significant (better than 5% level) correlation is reported between FM and EM, which is 0.130 (significant at the 1% level).

Altogether, the correlation statistics reveal that the greatest benefits of diversification for equity investors have clearly been available from the frontier markets, and in addition, that the return-generation patterns in the emerging markets have been surprisingly parallel to those in the three developed markets.

Table 3 shows that during the latter sub-period from January 2008 to December 2016, the cross-market correlations have clearly increased. The most striking increase has taken place in the co-movements of FM and other markets. While FM did not correlate significantly with the US and the Japanese markets during the first sub-period, the corresponding correlations are highly significant during the latter sub-period. The correlation coefficients of FM with the remaining two equity markets are also outstandingly higher and more significant during the latter sub-period than their counterparts during the first sub-period. The similar tendency towards tighter integration has taken place in all 10 pairwise comparisons. Interestingly, the highest pairwise correlation during both sub-periods is documented between EM and DE. Altogether, the results show that the cross-market return linkages have strengthened, thereby reducing the benefits of international diversification. At least in light of return correlations, both frontier markets and emerging markets have

Table 2. Cross-market correlations over the period from June 2002 to Dec 2007

	DE	Japan	EM	FM
US	0.631***	0.310***	0.510***	0.049
DE		0.364***	0.638***	0.083*
Japan			0.486***	0.072
EM				0.130***

This table shows the return correlation across the examined equity markets during the first sub-period from June 2002 to Dec 2007 (calculated based on 270 weekly returns). The correlation coefficients reported in this table have been adjusted to be straightly comparable with those reported in Table 3 (see footnote 8). The significance of the correlations at the 1%, 5%, and 10% level is shown by ***, **, and *, respectively.

Table 3. Cross-market correlations over the period from Jan 2008 to Dec 2016

	DE	Japan	EM	FM
US	0.776***	0.507***	0.736***	0.361***
DE		0.625***	0.849***	0.462***
Japan			0.634***	0.373***
EM				0.510***

This table shows the correlations across the examined equity markets during the second sub-period from Jan 2008 to Dec 2016 (calculated based on 490 weekly returns). The significance of the correlations at the 1%, 5%, and 10% level is shown by ***, **, and *, respectively.

started to behave more similarly to developed markets. The potential reason for this might be in the globalization of financial markets. While these two types of developing markets have earlier been relatively isolated from the developed markets, they have become more integrated during the third millennium. In emerging markets, this tendency of convergence has begun earlier, whereas, in frontier markets, the segmentation has prevailed longer.

4.2. 26-week rolling correlations

It is well known that cross-market correlations of equity returns vary remarkably over time. (e.g., see Akca & Ozturk, 2016; Aloui, Aïssa, & Nguyen, 2011; Longin & Solnik, 1995, 2001). Therefore, based on 26-week rolling time window, we also calculate correlations between EM and three developed markets, as well as between FM and the other examined four markets. Figures 1 and 2 show these rolling correlations for the whole period over which the correlation coefficients can be calculated (i.e. from the beginning of December 2002 to the end of 2016). The horizontal lines depict the threshold levels, above (below) which the coefficients are significantly positive (negative) at the 5% level (The thresholds are approximately at 0.388 and -0.388 , respectively). These results are in line with earlier literature in that significant time-variability is detected during both sub-periods. As far as overall intensity of pairwise correlations is concerned, the results are also consistent with those documented for both sub-periods. The strongest and the most persistent return correlation is documented for DE and EM, between which the rolling 26-week correlation is significant (at the 5% level) for the whole period over which the correlations can be calculated. The parallel relationship also exist between the US and EM markets, except that within both sub-periods, there are two short periods, during which their correlation has decreased to an insignificant level. The first of these took place a few months before the emergence of financial crisis when the corresponding rolling 26-week correlation turned momentarily negative. The increased co-movement of equity returns between EM and FM during the latter sub-period can also be detected on the basis of this analysis: the corresponding correlation coefficient is significant (at the 5% level) only in 54 out of 265 weeks for which the rolling 26-week correlation can be calculated in the first sub-period (i.e., approximately in one out of 5 weeks, on average), whereas during the latter sub-period, the same significance level is exceeded in 330 out of 470 weeks (i.e., approximately in seven out of 10 weeks, on average).

Figure 1. 26-week rolling correlations of MSCI emerging market (EM) index.

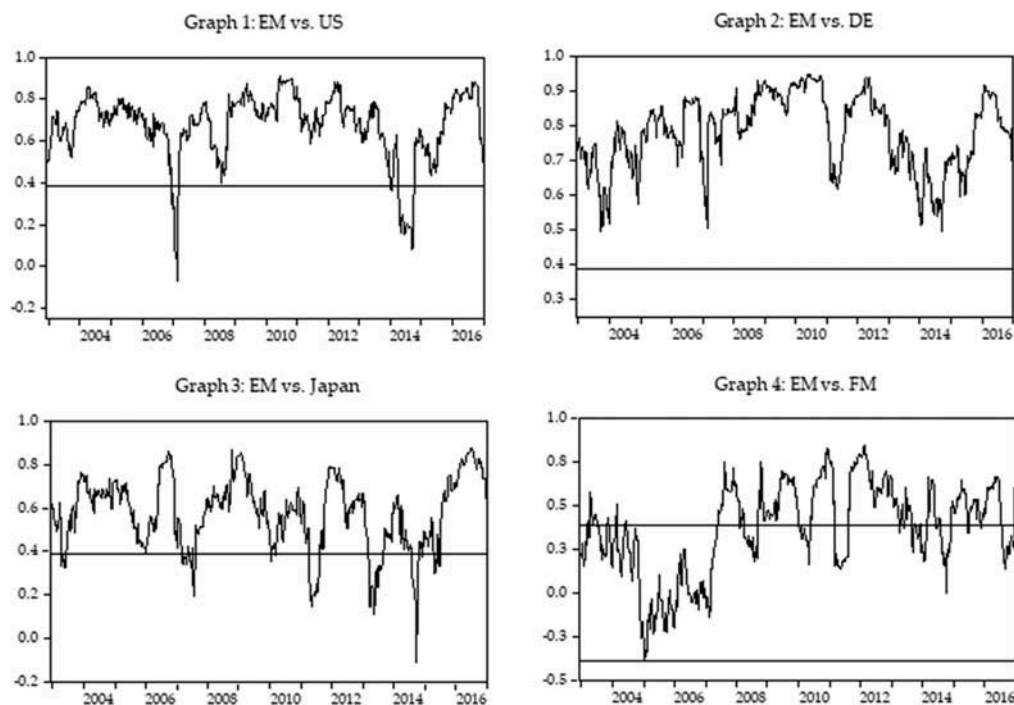
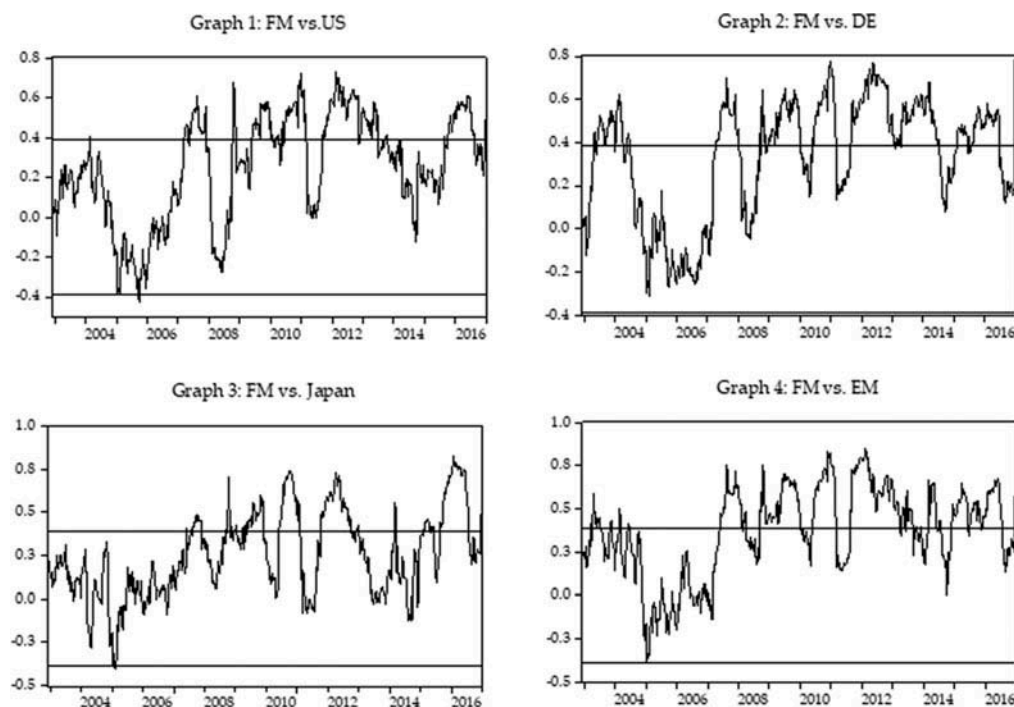


Figure 2. 26-week rolling correlations of MSCI frontier market (FM) index.



The 26-week rolling correlations between FM and three developed markets (depicted in Figure 2) also reinforces the overall correlation increase between these three pairs of markets during the latter sub-period. During the first sub-period, the correlation of FM with the developed European (US) markets have been significant and positive in 90 (37) out of 265 weeks (the corresponding proportions are 34.0% and 14.0%, respectively), whereas for the second sub-period, the corresponding correlations have been significant in 318 (228) out of 470 weeks (the corresponding proportions are 67.7% and 48.5%, respectively). Between FM and Japan, the 26-week rolling correlation, the occurrence frequencies of positive and significant 26-week rolling correlations for the two sub-periods are 6.8% for the first sub-period, and 43.0% for the second, also indicating the tendency towards increased cross-market correlations during the two crisis periods included in the latter sub-period.

4.3. Dependency of cross-market correlations on overall stock market volatility

Several earlier studies have reported that the volatility changes drive cross-market correlations (e.g., see Baele, 2005; Knif & Pynnönen, 2007; Kocaarslan, Soytas, Sari, & Ugurlu, 2019; Ramchand & Susmel, 1998). However, contrary evidence also exists (e.g., see Ang & Chen, 2002; Bartram & Wang, 2005). To examine the relations between the global stock market volatility and cross-market correlations, we run a simple correlation analysis by using 26-week rolling values of these two variables as a basis of the analysis. For the longest available sample period from the beginning of December 2002 to the end of 2016, the global stock market volatility (calculated on the basis of weekly returns of the MSCI All Country World Index) is documented to be positively related to cross-market correlations for every pair of the stock markets in which either EM or FM is another component of a pair (see Table 4). Thus, high volatility seems to increase cross-market correlations, and vice versa. The same also holds for both sub-periods, except that during the first sub-period, positive linear relationships between the global stock market volatility and the rolling cross-market correlation between EM and DE, and that between EM and Japan are not significant.

4.4. Spillovers between emerging and three developed markets

4.4.1. Spillovers during the full sample period (Jun 2002—Dec 2016)

Table 5 shows the parameters of the estimated model along with the corresponding standard errors. The VAR(1) return spillovers (parameters β_{12} , and β_{21}) are presented in Panel A, whereas

Table 4. Correlation of global stock market volatility with cross-market correlations

Periods	EM				FM		
	FM	US	DE	Japan	US	DE	Japan
12/2002-12/2016	0.440***	0.415***	0.556***	0.415***	0.310***	0.300***	0.435***
12/2002-12/2007	0.317***	0.105***	0.042	0.054	0.182***	0.152***	0.197***
01/2008-12/2016	0.249***	0.408***	0.531***	0.438***	0.131***	0.122***	0.274***

The table shows the correlation coefficients between the global stock market volatility (calculated based on 26-week rolling returns of the MSCI All Country World Index) and 26-week rolling cross-market correlations for every pair of the stock markets in which either EM or FM is another component. The rows show the pairs of the markets either with EM or FM. The first numerical row shows the results for the full sample period from December 2002 to December 2016. The coefficients shown on the second row are for the period from December 2002 to December 2007, whereas those shown on the bottom row are for the period from January 2008 to December 2016. The correlation coefficients reported in this table have been adjusted to be straightly comparable with those for the full sample period (see footnote 8). The significance of the correlations at the 1%, 5%, and 10% level is shown by ***, **, and *, respectively.

ARCH (i.e., shock) spillovers (parameters a_{12} and a_{21}) and volatility (i.e., GARCH) spillovers (parameters g_{12} and g_{21}) are shown in Panel B. With respect to return spillovers (Panel A), bi-directional linkages between US and EM are weakly significant (at the 10% level). By contrast, no significant return spillover is reported between DE and EM, whereas a uni-directional return spillover from Japan to EM is weakly significant (at the 10% level).

According to the results based on the BEKK-GARCH(1,1) model (Panel B), the bi-directional volatility transmission between EM and Japan is evident and significant at the 5% level, whereas volatility spillover effect between US and EM is uni-directional from the former to the latter. By contrast, no significant volatility transmission between EM and DE is reported. The results of insignificant return and volatility spillovers between EM and DE are somewhat surprising in light of the correlation analysis, according to which EM has had the strongest correlation with DE. Panel B also shows that EM has received shock spillovers from US and Japan and sent shock spillovers to DE uni-directionally. Among the developed markets examined, Japan has had both economically and statistically the most significant volatility spillover linkages with EM. The parameter estimates on the leading diagonals of BEKK-GARCH(1,1) model indicate that the conditional variance of each market depends very significantly on their own past shocks (a_{11} , a_{22}) and variances (g_{11} , g_{22}), respectively.

The diagnostic test results of the Ljung–Box Q-statistics are reported in Panel C of Table 5. These tests are used to check whether the selected model is correctly specified. The test shows overall insignificant Q-stats for standardized and squared standardized residuals of each market included in the regression equations, indicating that the estimated VAR(1)–BEKK-GARCH(1,1) model captures the ARCH effects in every market completely, thereby confirming the fitness of model for studying the spillovers in all three market pairs.

4.4.2. Spillovers during the first sub-period (Jun 2002–Dec 2007)

Table 6 shows the corresponding linkages of EM with the three developed markets over the sub-period from June 2002 to December 2007. During this 5 and ½-year period, the bi-directional return transmission between US and EM also existed and it was more significant (at the 5% level) than during the full sample period. Similar bi-directional volatility spillovers between the Japanese and emerging markets to those documented for the full sample period also existed during the first sub-period. By contrast, from June 2002 to December 2007, EM had significant shock spillover linkages only with DE and these linkages were bi-directional. This finding differs from the results for the full sample period, according to which EM only sent shock spillovers to DE, but received them from the US and the Japanese markets. These results imply that during the period of growth in the stock markets, the EM were more integrated with the US and DE in terms of return and shock spillovers, respectively, whereas they were integrated with the Japanese markets mostly through volatility transmissions. All diagonal parameter estimates are statistically significant at the 5%

Table 5. Spillovers between EM and other stock markets from June 2002 to December 2016

	EM-US		EM-DE		EM-Japan	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>						
θ_{11}	0.011	(0.049)	0.047	(0.054)	0.081**	(0.039)
θ_{12}	0.102*	(0.059)	-0.019	(0.055)	-0.061*	(0.036)
μ_1	0.002**	(0.001)	0.003***	(0.001)	0.003***	(0.001)
θ_{21}	-0.052*	(0.031)	0.022	(0.049)	0.056	(0.034)
θ_{22}	-0.026	(0.044)	-0.136**	(0.054)	-0.047	(0.038)
μ_2	0.002**	(0.001)	0.003***	(0.001)	0.001	(0.001)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>						
c_{11}	0.009***	(0.001)	0.008***	(0.002)	0.007***	(0.002)
c_{12}	0.004***	(0.001)	0.003***	(0.001)	-0.006***	(0.002)
c_{22}	0.002**	(0.001)	0.005***	(0.001)	0.023-e4	(0.032)
a_{11}	0.382***	(0.059)	0.248***	(0.094)	0.418***	(0.044)
a_{12}	0.099**	(0.050)	-0.025	(0.098)	0.178***	(0.043)
a_{21}	0.018	(0.083)	0.190**	(0.086)	-0.033	(0.044)
a_{22}	0.292***	(0.065)	0.362***	(0.088)	0.172***	(0.047)
g_{11}	0.858***	(0.039)	0.918***	(0.080)	0.952***	(0.045)
g_{12}	-0.071**	(0.029)	0.083	(0.075)	0.524***	(0.115)
g_{21}	0.025	(0.035)	-0.057	(0.071)	-0.299*	(0.153)
g_{22}	0.962***	(0.029)	0.847***	(0.067)	-0.990***	(0.041)
<i>Panel C: Diagnostic tests</i>						
LogLik		3820.037		3789.577		3456.472
LB_1		25.724		24.394		22.914
LB_2		30.427		22.336		24.483
LB^2_1		22.042		19.297		21.285
LB^2_2		25.517		24.471		27.459

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between EM and three developed markets examined. In Panel A, θ_{11} and θ_{22} represent the autocorrelation in returns of market 1 and 2, respectively, whereas θ_{12} and θ_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always EM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q-statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for EM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. The number of weekly observations for each market is 760 over the full sample period from June 2002 till December 2016.

level, thereby indicating that during the first sub-period, the autocorrelation and persistence of volatility transmission were high.

In line with the results for the full-length sample period, the diagnostic statistics in Panel C show no significant serial correlation for the standardized residuals. However, for this sub-period, the null of no significant ARCH effect is rejected in the case of DE (at the 5% significance level) due to heteroscedasticity in the squared standardized residuals. Nevertheless, the log-likelihood values remain very high, even when related to the number of time-series observations, thereby indicating

Table 6. Spillovers between EM and other stock markets from June 2002 to December 2007

	EM-US		EM-DE		EM-Japan	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>						
θ_{11}	-0.121	(0.076)	0.005	(0.092)	0.052	(0.065)
θ_{12}	0.273***	(0.105)	0.078	(0.103)	-0.075	(0.053)
μ_1	0.005***	(0.001)	0.006***	(0.001)	0.006***	(0.001)
θ_{21}	-0.140***	(0.043)	-0.066	(0.073)	0.070	(0.055)
θ_{22}	0.096	(0.075)	-0.040	(0.086)	-0.112*	(0.064)
μ_2	0.002**	(0.001)	0.005***	(0.001)	-0.085-e3	(0.001)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>						
c_{11}	0.010***	(0.002)	0.005**	(0.002)	0.011***	(0.003)
c_{12}	0.004***	(0.001)	0.002	(0.002)	0.003	(0.002)
c_{22}	0.002**	(0.001)	0.002**	(0.001)	-0.049-e5	(0.006)
a_{11}	0.336***	(0.091)	0.694***	(0.102)	0.350***	(0.098)
a_{12}	0.017	(0.060)	0.451***	(0.084)	0.094	(0.107)
a_{21}	-0.080	(0.165)	-0.752***	(0.121)	0.007	(0.079)
a_{22}	0.196**	(0.089)	-0.562***	(0.093)	0.239***	(0.073)
g_{11}	0.830***	(0.068)	0.952***	(0.060)	0.798***	(0.062)
g_{12}	-0.049	(0.046)	0.028	(0.053)	-0.099**	(0.039)
g_{21}	0.069	(0.062)	-0.122**	(0.054)	0.059*	(0.033)
g_{22}	0.986***	(0.038)	0.889***	(0.039)	0.993***	(0.015)
<i>Panel C: Diagnostic tests</i>						
LogLik		1524.923		1517.111		1340.021
LB_1		28.609		30.246		25.465
LB_2		31.379		26.861		16.308
LB^2_1		13.303		17.526		12.373
LB^2_2		18.028		38.543**		15.103

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between EM and three developed markets examined. In Panel A, β_{11} and β_{22} represent the autocorrelation in returns of market 1 and 2, respectively whereas β_{12} and β_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always EM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q-statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for EM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The number of weekly observations for each market is 290 over the period from June 2002 till December 2007.

the overall appropriateness of the BEKK-GARCH(1,1) model for analyzing spillover effects during this sub-period as well.

4.4.3. Spillovers during the second sub-period (Jan 2008—Dec 2016)

Table 7 shows the spillover statistics for the latter sub-period. Panel A shows that no statistically significant return spillover existed between EM and the developed markets being examined. This is also the most striking change in the spillover effects between EM and the developed equity markets during the latter sub-period. Regarding shock spillovers during this period, bi-directional shock effects

Table 7. Spillovers between EM and other stock markets from January 2008 to December 2016

	EM-US		EM-DE		EM-Japan	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>						
θ_{11}	0.070	(0.070)	0.103	(0.072)	0.096**	(0.048)
θ_{12}	0.090	(0.076)	-0.050	(0.063)	-0.035	(0.045)
μ_1	0.000	(0.001)	0.001	(0.001)	0.001	(0.001)
θ_{21}	-0.040	(0.051)	0.107	(0.072)	0.042	(0.038)
θ_{22}	-0.096	(0.064)	-0.173**	(0.071)	-0.031	(0.044)
μ_2	0.003***	(0.001)	0.002**	(0.001)	0.002**	(0.001)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>						
c_{11}	0.007	(0.006)	0.004	(0.004)	0.000	(0.064)
c_{12}	-0.003	(0.011)	0.003	(0.002)	-0.003	(0.003)
c_{22}	0.002	(0.003)	0.009***	(0.002)	0.015***	(0.003)
a_{11}	0.735***	(0.080)	0.260**	(0.124)	0.450***	(0.050)
a_{12}	0.446***	(0.058)	-0.033	(0.153)	0.298***	(0.060)
a_{21}	-0.702***	(0.093)	0.191*	(0.108)	-0.005	(0.066)
a_{22}	-0.738***	(0.066)	0.367**	(0.148)	0.065	(0.086)
g_{11}	0.830***	(0.074)	1.055***	(0.142)	0.957***	(0.028)
g_{12}	0.029	(0.045)	0.260*	(0.141)	0.319**	(0.140)
g_{21}	0.003	(0.072)	-0.201	(0.139)	-0.349**	(0.158)
g_{22}	0.845***	(0.042)	0.670***	(0.136)	-0.733**	(0.148)
<i>Panel C: Diagnostic tests</i>						
LogLik		2319.774		2300.695		2129.630
LB_1		21.993		12.484		13.536
LB_2		24.556		19.431		17.346
LB^2_1		32.465		21.908		21.175
LB^2_2		32.243		25.927		39.341**

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between EM and three developed markets examined. In Panel A, θ_{11} and θ_{22} represent the autocorrelation in returns of market 1 and 2, respectively whereas θ_{12} and θ_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always EM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q-statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for EM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The number of weekly observations for each market is 470 over the period from January 2008 till December 2016.

between EM and U.S. markets have existed at the 1% level of significance. These results show a changed spillover linkage between these two markets, as during the first period, the US market had no statistically significant shock spillover effects with EM. In addition, a uni-directional shock transmission from Japan to EM has taken place, whereas a weakly significant (at the 10% level) shock transmission is documented from EM to DE. Interestingly, the direction of volatility transmission between DE and EM (which is also weakly significant at the 10% level) is reverse to that of the corresponding shock transmission. In addition, the Japanese market remained closely inter-linked

with EM during this period due to bi-directional volatility transmission, whereas volatility spillovers between EM and the U.S. were practically nonexistent.

The diagnostic test statistics show that also for the latter sub-period, the VAR(1)–BEKK–GARCH (1,1) specification captures the ARCH effect quite well, with the only exception being the Japanese market, for which the null of homoscedasticity is rejected at the 5% level.

4.5. Spillovers between the frontier (FM) and the other four markets

4.5.1. Spillovers during the full sample period (Jun 2002–Dec 2016)

Table 8 shows the spillover linkages of FM with the three developed markets and EM over the full-sample period from June 2002 to December 2016. DE is the only market with which FM has had a significant bi-directional return spillover linkage. Panel A further shows that FM has also received uni-directional return spillovers from US and EM. In terms of shock and volatility transmissions (Panel B), FM and EM have had significant bi-directional spillovers, while spillover linkages between FM and U.S. markets has been uni-directional from the former to the latter. Altogether, the spillover results are consistent with the corresponding correlation results, as most of the significant linkages with FM are documented for EM that also correlated most with FM during both sub-periods. However, there is not even weakly significant (at the 10% level) spillover linkages between FM and Japan indicating that in terms of spillover effects, these two markets have remained segregated during the full sample period.

The diagnostic test statistics show the overall fitness of the model as log-likelihood values are high in every case, even though the Ljung–Box Q -statistics (denoted by LB in Panel C) for the standardized residuals show the existence of autocorrelation in the cases of FM. However, the corresponding statistics (LB^2) for the squared standardized residuals are insignificant, except for the US, implying the absence of the ARCH effect for all the other markets.

This full sample period analysis of each pair, in which frontier market is another of the two portfolios being compared, reveals that frontier markets are generally less integrated with developed equity markets than emerging markets. This is likely the result of international investors' low attention on frontier markets at the beginning of the emergence of these potential markets. As long as frontier markets are dominated by domestic investors, the stock prices in the local stock exchanges are also determined by the same group of investors. This enables such markets to remain rather isolated and relatively immune to external shocks. As international institutional investors start to get interested in these markets and decide to allocate their wealth there to maximize their diversification benefits to the extent that they begin to dominate the price setting in the local stock exchange instead of domestic investors, the market starts to co-move more with other stock markets and becomes more vulnerable to spillovers.

4.5.2. Spillovers during the first sub-period (Jun 2002–Dec 2007)

During the first sub-period from June 2002 to Dec 2007, a significant return spillover to FM is documented from US, DE and EM (see Table 9). By contrast, FM has not sent any significant return spillovers to any of the examined counterpart markets. However, a significant uni-directional shock spillover from EM to FM, as well as from DE to FM has existed, while all the counter-directional shock spillovers to FM have been insignificant (see panel B). Moreover, volatility spillovers from or to FM have not existed during this sub-period at any reasonable level of significance. This implies that at least in terms of financial contagion, FM was neither statistically nor economically very much integrated with the rest of equity markets during the period of stock market growth. Interestingly, the US market has not shown any level of integration with FM and the role of DE is minimal.

However, the persistence of shocks and volatility within each market is again evident across all the markets. Very low interdependence of frontier markets during the period 2002–2007 is in line with our earlier conjecture that frontier markets did not receive a lot of attention from

Table 8. Spillovers between FM and other stock markets from June 2002 to December 2016

	FM-US		FM-DE		FM-Japan		FM-EM	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>								
θ_{11}	0.107***	(0.033)	0.089***	(0.032)	0.168***	(0.037)	0.108***	(0.032)
θ_{12}	0.176***	(0.025)	0.114***	(0.019)	0.026	(0.021)	0.135***	(0.021)
μ_1	0.002**	(0.001)	0.002**	(0.001)	0.002**	(0.001)	0.002**	(0.001)
θ_{21}	0.019	(0.032)	0.068*	(0.041)	0.007	(0.045)	0.068	(0.049)
θ_{22}	-0.082**	(0.039)	-0.102***	(0.036)	-0.023	(0.036)	0.025	(0.037)
μ_2	0.003***	(0.001)	0.003***	(0.001)	0.002**	(0.001)	0.003***	(0.001)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>								
c_{11}	0.003***	(0.001)	0.003***	(0.001)	0.003***	(0.001)	0.003***	(0.001)
c_{12}	0.002**	(0.001)	0.001	(0.001)	0.003***	(0.001)	0.002**	(0.001)
c_{22}	0.005***	(0.001)	0.006***	(0.001)	0.007***	(0.002)	0.009***	(0.001)
a_{11}	0.369***	(0.040)	0.392***	(0.040)	0.416***	(0.039)	0.332***	(0.046)
a_{12}	-0.078	(0.054)	-0.094	(0.058)	0.083	(0.054)	-0.208***	(0.072)
a_{21}	0.076**	(0.030)	0.022	(0.028)	-0.017	(0.028)	0.085***	(0.030)
a_{22}	0.373***	(0.036)	0.360***	(0.034)	0.230***	(0.046)	0.409***	(0.044)
g_{11}	0.909***	(0.018)	0.900***	(0.019)	0.898***	(0.017)	0.923***	(0.020)
g_{12}	0.031	(0.027)	0.034	(0.031)	-0.022	(0.021)	0.096**	(0.040)
g_{21}	-0.035**	(0.017)	-0.007	(0.013)	-0.026	(0.018)	-0.052***	(0.019)
g_{22}	0.896***	(0.021)	0.910***	(0.017)	0.934***	(0.024)	0.852***	(0.031)
<i>Panel C: Diagnostic tests</i>								
<i>LogLik</i>		3972.045		3815.956		3735.931		3789.198
LB_1		72.441***		71.031***		60.997***		55.486***
LB_2		27.899		19.700		26.525		19.571
LB^2_1		11.497		13.487		15.893		12.434
LB^2_2		41.727**		31.679		31.524		31.835

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between FM and the four other markets examined. In Panel A, θ_{11} and θ_{22} represent the autocorrelation in returns of market 1 and 2, respectively whereas θ_{12} and θ_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always FM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q-statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for FM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The number of weekly observations for each market is 760 over the period from June 2002 till December 2016.

international investors during the before-crisis period. These results are also in accordance with some earlier literature, according to which the integration of new frontier markets with the major developed markets has generally been low in the beginning when they have just been identified as potential sources for portfolio diversification (e.g., see Guney, Kallinterakis, & Komba, 2017; Speidell & Krohne, 2007). In most cases, the low correlations have been explained by political and economic risks that have been too high to attract investors from developed markets (Abidi, Hacibedel, & Nkusu, 2016).

Table 9. Spillovers between FM and other stock markets from June 2002 to December 2007

	FM-US		FM-DE		FM-Japan		FM-EM	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>								
θ_{11}	0.219***	(0.059)	0.189***	(0.060)	0.247***	(0.058)	0.218***	(0.057)
θ_{12}	0.139***	(0.045)	0.116***	(0.039)	0.006	(0.033)	0.087***	(0.032)
μ_1	0.004***	(0.001)	0.004***	(0.001)	0.004***	(0.001)	0.003***	(0.001)
θ_{21}	0.022	(0.047)	0.058	(0.067)	0.039	(0.077)	0.099	(0.083)
θ_{22}	-0.054	(0.066)	-0.102*	(0.061)	-0.057	(0.063)	-0.006	(0.062)
μ_2	0.002**	(0.001)	0.004***	(0.001)	0.000	(0.001)	0.005**	(0.002)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>								
c_{11}	0.003	(0.003)	0.003***	(0.001)	0.002**	(0.001)	0.003***	(0.001)
c_{12}	-0.001	(0.006)	0.002	(0.002)	0.002**	(0.001)	0.002**	(0.001)
c_{22}	0.002	(0.002)	0.004**	(0.002)	0.005**	(0.002)	0.010***	(0.003)
a_{11}	0.277***	(0.068)	0.310***	(0.057)	0.251***	(0.057)	0.247***	(0.060)
a_{12}	-0.090	(0.060)	-0.159**	(0.069)	0.016	(0.110)	-0.269***	(0.102)
a_{21}	-0.009	(0.049)	0.010	(0.044)	-0.006	(0.029)	0.041	(0.041)
a_{22}	0.224***	(0.047)	0.255***	(0.063)	0.252***	(0.064)	0.340***	(0.077)
g_{11}	0.940***	(0.029)	0.925***	(0.025)	0.948***	(0.024)	0.945***	(0.021)
g_{12}	0.041	(0.026)	0.050	(0.034)	-0.005	(0.035)	0.076	(0.050)
g_{21}	-0.002	(0.021)	-0.018	(0.024)	-0.012	(0.012)	-0.045	(0.030)
g_{22}	0.964***	(0.018)	0.936***	(0.032)	0.951***	(0.025)	0.840***	(0.067)
<i>Panel C: Diagnostic tests</i>								
LogLik		1574.532		1519.242		1437.588		1463.027
LB_1		19.585		16.212		15.367		13.325
LB_2		23.438		27.571		15.495		23.060
LB^2_1		17.535		24.350		24.195		21.993
LB^2_2		26.312		31.095		13.355		17.720

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between FM and the four other markets examined. In Panel A, θ_{11} and θ_{22} represent the autocorrelation in returns of market 1 and 2, respectively whereas θ_{12} and θ_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always FM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q -statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for FM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The number of weekly observations for each market is 290 over the period from June 2002 till December 2007.

For this sub-period, the post-estimation log-likelihood values are also high, and none of the Ljung-Box Q -statistics is significant, thereby indicating that the employed VAR(1)-BEKK-GARCH (1,1) framework fits well to capture the autocorrelation and autoregressive conditional heteroscedasticity in residuals for each market.

4.5.3. Spillovers during the second sub-period (Jan 2008—Dec 2016)

During the latter sub-period from January 2008 to December 2016, a return spillover pattern for FM is very similar to that observed during the first sub-period (Table 10, Panel A): US, DE and EM have

Table 10. Spillovers between FM and other stock markets from January 2008 to December 2016

	FM-US		FM-DE		FM-Japan		FM-EM	
Parameters	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
<i>Panel A: VAR(1) estimates</i>								
θ_{11}	0.026	(0.058)	0.027	(0.045)	0.141***	(0.046)	0.010	(0.048)
θ_{12}	0.163***	(0.035)	0.108***	(0.025)	0.050*	(0.027)	0.168***	(0.027)
μ_1	0.001	(0.001)	0.001	(0.001)	0.001	(0.001)	0.001	(0.001)
θ_{21}	0.025	(0.056)	0.048	(0.067)	0.024	(0.057)	-0.019	(0.071)
θ_{22}	-0.113**	(0.052)	-0.122*	(0.052)	-0.055	(0.044)	0.058	(0.052)
μ_2	0.003***	(0.001)	0.003**	(0.001)	0.001	(0.001)	0.001	(0.001)
<i>Panel B: BEKK-GARCH(1, 1) estimates</i>								
c_{11}	0.002	(0.004)	0.003***	(0.001)	-0.000	(0.004)	0.004***	(0.001)
c_{12}	0.003	(0.002)	0.002**	(0.001)	0.001	(0.001)	0.002**	(0.001)
c_{22}	0.008***	(0.001)	0.008***	(0.001)	0.023***	(0.002)	0.008***	(0.002)
a_{11}	0.343**	(0.137)	0.354***	(0.065)	0.464***	(0.055)	0.376***	(0.085)
a_{12}	-0.249***	(0.092)	-0.237***	(0.083)	-0.215**	(0.087)	-0.193	(0.130)
a_{21}	0.143**	(0.070)	0.110***	(0.036)	-0.035	(0.038)	0.087	(0.053)
a_{22}	0.345***	(0.080)	0.387***	(0.056)	0.234***	(0.081)	0.457***	(0.072)
g_{11}	0.957***	(0.057)	0.924***	(0.036)	0.921***	(0.022)	0.895***	(0.045)
g_{12}	0.334***	(0.068)	0.190***	(0.058)	0.321***	(0.087)	0.090	(0.086)
g_{21}	-0.213***	(0.040)	-0.069**	(0.028)	-0.189***	(0.043)	-0.038	(0.036)
g_{22}	0.736***	(0.046)	0.835***	(0.035)	0.180	(0.231)	0.844***	(0.061)
<i>Panel C: Diagnostic tests</i>								
LogLik		2420.347		2308.130		2308.996		2337.651
LB_1		47.445***		45.948***		45.276***		49.348***
LB_2		23.942		19.380		17.521		14.059
LB^2_1		15.157		12.422		12.933		16.837
LB^2_2		35.986*		33.525		35.655*		29.554

This table shows the estimated parameters of VAR(1) Equation (1) and of BEKK-GARCH(1,1) Equation (7) between FM and the four other markets examined. In Panel A, θ_{11} and θ_{22} represent the autocorrelation in returns of market 1 and 2, respectively whereas θ_{12} and θ_{21} represent the cross-market return spillovers. The parameters μ_1 and μ_2 are the intercepts of the respective market. In Panel B, coefficients (c) are intercepts of BEKK-GARCH(1,1) model, while diagonal coefficients (a_{11} and a_{22}) capture own and off-diagonal coefficients (a_{12} and a_{21}) capture cross-market ARCH (shock spillover) effects. Similarly, the diagonal (g_{11} and g_{22}) and off-diagonal (g_{12} and g_{21}) coefficients indicate own and cross-market GARCH (volatility spillover) effects, respectively. In Panel C, LB and LB^2 represents the Ljung-Box Q-statistic for standardized mean and squared residuals, respectively. Corresponding standard errors (S.E.) of all estimated coefficients are shown in parentheses. The subscript numbers of coefficients refer to the pairs of markets examined so that the first market of each pair shown on the top row (which in this table is always EM) is denoted by 1, whereas the other market is denoted by 2. For each cross-market spillover slope, the latter number in a subscript indicates the origin market of a spillover, whereas the first subscript indicates the receiving market. In the cases where two subscripts are equal, the regression slopes indicate the corresponding intra-market effects. In Panel C, LB and LB^2 show the Ljung-Box Q-statistic for standardized and squared standardized residuals of the BEKK-GARCH(1,1) specifications for FM (denoted by subscript 1) and other markets (denoted by subscript 2), respectively. *, ** and *** denote the level of significance at 10%, 5% and 1%, respectively. The number of weekly observations for each market is 470 over the period from January 2008 till December 2016.

all sent return spillovers to FM, but the corresponding counter-directional return transmissions have not occurred. In addition, a return spillover from Japan to FM has also been weakly significant (at the 10% level). Interestingly, volatility spillovers have become more common and significant during the latter sub-period, as this period includes the global financial crisis period, as well as the Euro-zone crisis period.

Panel B clearly indicates that in terms of shock and volatility spillovers, the interdependence of FM was very strong with the developed markets (lacking only a shock transmission to Japan), whereas the corresponding spillovers between FM and EM were, quite surprisingly, negligible and statistically insignificant. This indicates that during the latter sub-period, volatility spillovers from/to FM have been more closely tied with the developed markets than with the emerging markets. This finding is in contrast with the results for the full sample period, according to which both shock and volatility spillovers between FM and EM have been significant and bi-directional. With this respect, the results for the latter sub-period are also in contrast with those for the first sub-period, based on which no significant volatility transmission has occurred with FM and EM, and only uni-directional shock spillover from EM to FM was documented. Because the results of volatility spillover between FM and EM are significant for the full sample period, but at the same time, insignificant for both sub-periods, the corresponding volatility spillovers must indeed have also existed during the sub-periods, but their intensity with respect to the number of observations has not been strong enough for statistical significance. Altogether, overall results prove that the financial crisis has really changed the linkages between the examined five equity markets. Particularly, the role of FM has drastically changed from an isolated market during the pre-crisis period to a more integrated market during and after the crisis.

The log-likelihood values in panel C are high implying that the overall fitness of the VAR(1)–BEKK–GARCH(1,1) model is good. However, the Ljung–Box Q-statistics behave similarly as in the full sample period (in Table 8), indicating a significant autocorrelation in residuals in all four cases of FM. By contrast, all the corresponding Q-statistics for the squared standardized residuals are insignificant at the 5% level, implying that the ARCH effect is at least moderately captured by the model employed.

5. Discussion and conclusions

This study provides new evidence on the changing role of emerging and frontier stock markets during the twenty-first century. Generally, our results show that these two markets have become more integrated with the developed markets. In emerging markets, a similar integration tendency have begun earlier, whereas in frontier markets, the convergence has outstandingly increased as a result of the recent financial crisis.

We examine three different types of spillover effects that are return, shock, and volatility spillovers. In terms of return spillovers, the emerging markets have had the strongest linkages with the U.S. markets, whereas the frontier markets have had the strongest linkages with DE. Regarding shock spillovers, the strongest linkages during the full sample period, as well as in the first sub-period, are documented between the emerging and frontier markets. However, during the second sub-period, shock linkages changed so that the role of the U.S. markets as both a shock transmitter as well as a shock receiver increased with respect to both emerging and frontier stock markets. By contrast, the intensity of shock spillovers between these two developing markets somewhat attenuated during the latter sub-period. Similar to shock spillovers, volatility transmissions were also bi-directional and significant between the two last-mentioned markets during the full sample period. Within the same time-span, a similar pattern in volatility spillover also existed between the emerging and Japanese equity markets. During the latter sub-period, the spillover linkages between Japan and the emerging markets, as well as between Japan and the frontier markets, increased.

The overall results show that both emerging and frontier markets have started to co-move more with the developed stock markets to the extent that the benefits of international diversification to the two first-mentioned markets have clearly decreased. This convergence tendency has been stronger in emerging markets than in frontier markets, and therefore, investors should consider increasing the weight of frontier markets in their equity portfolios, if they liked to optimize the benefits of international diversification. In addition, they should diversify to such frontier markets that are either at a low weight in the frontier market indices or not yet included in such indices at all. However, such weight increase is

not riskless with respect that during turbulent times, the stock prices tend to decline more in a thinly traded markets as a result of mass selling activities of international investors in such market conditions (e.g., see Ahmed, 2016; Jeon & Moffett, 2010; Kim & Wei, 2002; Sarno & Taylor, 1999). On the other hand, it is important to note that the diversification benefits of investing in emerging and frontier markets are most probably greater if these two developing markets are divided into distinct national or regional markets instead of treating them as two separate asset-class portfolios.⁹ By following a selective diversification strategy, in which the national or regional markets within emerging and frontier markets are chosen among those with lowest correlations with the globally diversified developed market portfolio, the same total weight given for emerging and frontier markets in a global equity portfolio would provide more diversification benefits than in the case, where these markets would be weighted in accordance with their index weights.¹⁰

In future studies, it would be interesting to examine whether the increased convergence of equity markets is a persistent or a time-varying phenomenon. Based on the strong variability in the rolling correlation coefficients between the examined stock markets over time, it is likely that the relations documented for the sample periods are, at least to some extent, period-specific. However, overall globalization of equity markets might imply that once the developing markets have been included as a part of internationally diversified portfolio, the cross-market correlations would not necessarily revert to as low level as they were before the convergence tendency began. Therefore, investors should start to seek diversification benefits from the less-established frontier markets that are sufficiently developed to be of interest to investors, but that are simultaneously either at a decent weight in the MSCI FM Index or not yet included in that index at all. Beside the 28 national frontier markets included in the current MSCI FM Index, there are some potential frontier markets outside the index, which would, as a part of frontier market sub-portfolio and without any dramatic additional risk, offer higher diversification benefits as well as first-mover advantages to global investors.

Author details

Eero Pätäri¹
 E-mail: eero.patari@lut.fi
 Sheraz Ahmed¹
 E-mail: sheraz.ahmed@lut.fi
 ORCID ID: <http://orcid.org/0000-0001-6836-2030>
 Elena John¹
 E-mail: jelena.a.fedorova@gmail.com
 Ville Karell¹
 E-mail: ville.karell@gmail.com

¹ School of Business and Management, LUT University, Lappeenranta, Finland.

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Notes

1. Amin and Orlowski (2014) reported similar results on the relationship between developed and three Asian frontier markets.
2. We chose this specific date because it is approximately in the middle of 7 August 2007 that is deemed as the starting point of financial crisis in the developed markets (e.g. see Bekaert et al., 2014), and 20 May 2008, when the crisis escalated into emerging markets (e.g., see Hacihasanoglu et al., 2012). As our sample includes data from both developed and developing markets, we employ this compromise date for the sub-period division.
3. Because of a high number of countries included in these two types of developing markets, it would be impossible to report the corresponding results for

each of these national markets without losing transparency.

4. Among various alternative GARCH specifications, we use the bivariate BEKK-GARCH(1,1) because it allows the conditional variances and covariances of two markets to influence each other, while retaining sufficient generality. It also has an attractive property of positive definiteness of the conditional covariance matrix to ensure non-negative variance estimates. Of multivariate BEKK-GARCH models, we choose the bivariate specification because it is suitable for determining cross-dynamics of conditional covariances without any restrictions for the matrices A_{11} and G_{11} to be diagonal and it does not require estimation of many parameters, unlike the majority of more sophisticated GARCH specifications. The BEKK-GARCH(1,1) specification has also been widely used in order to trace shock and/or volatility spillovers in previous literature (see, e.g., Baele, 2005; Begiazi, Asteriou, & Pilbeam, 2016; Beirne, Caporale, Schulze-Ghattas, & Spagnolo, 2013; Caporale et al., 2006; Ghorbel & Boujelbene, 2013; Hung, 2019; Malik & Hammoudeh, 2007; Saleem, 2009).
5. The MSCI Frontier Markets Index was launched in December 2007 but it was back-calculated from June 2002, originally including 19 countries. As of 31 October 2019, the MSCI FM Index included 28 countries, among which clearly the highest country weight is given to Kuwait (its weight was 30.21% of the total market cap of the FM Index), followed by Vietnam with the weight of 18.77% (<https://www.msci.com/documents/10199/f9354b32-04ac-4c7e-b76e-460848afe026>). The MSCI Emerging Markets Index was launched in December 1987

originally including 10 countries. As of 29 March 2019, the MSCI EM Index included 26 countries, among which clearly the highest country weight (i.e. 33.00%) was held by China (<https://www.msci.com/emerging-markets>). Over time, some migration from the MSCI EM index to the MSCI Developed Market Index and back, as well as the corresponding migration between the MSCI FM Index to the MSCI EM Index, has occurred (see, e.g., Melas, 2019; Speidell, 2011).

6. The skewness- and kurtosis-adjustment is made by multiplying the standard deviation by the ratio Z_{CF}/Z_c , where Z_c is the critical value of the probability based on the standard normal distribution (set to—1.96 to correspond to the 95% probability level, in line with Favre & Galéano, 2002; Pätäri & Tolvanen, 2009), and Z_{CF} is the corresponding skewness- and kurtosis-adjusted value calculated on the basis of the fourth-order Cornish and Fisher (1938) expansion as follows: $Z_{CF} = Z_c + (Z_c^2 - 1)S/6 + (Z_c^3 - 3Z_c)K/24 - (2Z_c^3 - 5Z_c)S^2/36$, where S refers to Fisher's skewness and K to excess kurtosis.
7. It should be noted that the MDDs for EM and FM were determined on the basis of EM and FM portfolios of stocks domiciled in numerous emerging and/or frontier market countries and therefore, the MDDs for individual emerging or frontier markets have been even higher in many cases, and in addition, the corresponding drawdown periods may also have been shorter (e.g., Pätäri, Luukka, Fedorova, & Garanina, 2017 reported the MDD of—73.57% for the Russian stock market, having been realized within only a half-year period from 20th of May to the 21st of November 2008).
8. Following Pätäri (2011), the correlation coefficients reported in Table 2 have been adjusted to correspond to those in Table 3 in order to enable the straightforward comparability between the sub-periods. The adjustment were done on the basis of significance levels of t -statistics, by deriving the adjusted correlation coefficient for which the significance level is the same as originally, but with higher degrees of freedom determined on the basis of the number of observations included in the second sub-period. For example, if the original significance level during the first sub-period was 5%, the corresponding adjusted correlation coefficient would be approximately 0.0886 with 488 degrees of freedom.
9. At the time of writing this (i.e., in November 2019), the MSCI EM Index is dominated by Chinese stocks, which represent approximately one-third of its total market capitalization. MSCI has announced that it will increase the percentage of domestic Chinese stocks' (i.e., class A shares) free float included in the index from 5% to 20% by December 2019 (Melas, 2019). Ceteris paribus, this will further increase the country weight of China in the MSCI EM Index. Given that the next three highest country weights are held by South Korea, Taiwan and India, representing together more than 30% of total market cap of the MSCI EM, the index has currently a very heavy regional tilt towards Asia. Correspondingly, the MSCI FM Index is dominated by two countries as approximately half of its total market capitalization consists of the stocks domiciled in Kuwait and Vietnam (see endnote 5 and the related references therein).
10. Such a selective diversification strategy could be based on exploiting the well-documented regional differences in the interdependencies between the

developing and developed markets (e.g., see Ahmad et al., 2013; Bekaert et al., 2014; Samarakoon, 2011). By following such a strategy, the heavy country and/or regional tilts discussed in the previous endnote could also be avoided. It is also noteworthy that investing in the developing markets' capitalization-weighted indices may result in remarkable industry exposures: For example, as of 31 October 2019, the sector weight of financial companies in the MSCI FM index (as percentage of total market cap of the index) was as high as 47.91%. For investors, these kinds of unintended tilts give further motivation to diversify more within the developing markets than is enabled by investing just in the broad capitalization-weighted indices.

References

- Abidi, N., Hacibedel, M. B., & Nkusu, M. M. (2016). Changing times for frontier markets: A perspective from portfolio investment flows and financial integration. *IMF Working Paper*, 16(177). doi:10.13140/RG.2.2.14125.49127
- Ahmad, W., Sehgal, S., & Bhanumurthy, N. R. (2013). Eurozone crisis and BRIICKS stock markets: Contagion or market interdependence? *Economic Modelling*, 33, 209–225. doi:10.1016/j.econmod.2013.04.009
- Ahmed, W. M. A. (2016). Cross-border equity flows and market volatility: The case of Qatar Exchange. *International Journal of Emerging Markets*, 11(3), 395–418. doi:10.1108/IJOEM-11-2013-0177
- Akca, K., & Ozturk, S. S. (2016). The effect of 2008 crisis on the volatility spillovers among six major markets. *International Review of Finance*, 16(1), 169–178. doi:10.1111/irfi.12071
- Aloui, R., Aïssa, M. S. B., & Nguyen, D. K. (2011). Global financial crisis, extreme interdependences, and contagion effects: The role of economic structure? *Journal of Banking and Finance*, 35(1), 130–141. doi:10.1016/j.jbankfin.2010.07.021
- Amin, A. S., & Orlowski, L. T. (2014). Returns, volatilities, and correlations across mature, regional, and frontier markets. *Emerging Markets Finance & Trade*, 50(3), 5–27. doi:10.2753/REE1540-496X500301
- Ammer, J., Cai, F., & Scotti, C. (2011). Has International financial co-movement changed? Emerging markets in the 2007–2009 financial crisis. In J. A. Batten & P. G. Szilagyi (Eds.), *The impact of the global financial crisis on emerging financial markets (Contemporary studies in economic and financial analysis, volume 93)* (pp. 231–253). Bingley, UK: Emerald Group Publishing Limited. doi: 10.1108/S1569-3759(2011)0000093003
- Ang, A., & Chen, J. (2002). Asymmetric correlations of equity portfolios. *Journal of Financial Economics*, 63(3), 443–494. doi:10.1016/S0304-405X(02)00068-5
- Baba, Y., Engle, R. F., Kraft, D., & Kroner, K. F. (1989). Multivariate simultaneous generalized ARCH. *Working paper*, University of California in San Diego, Department of Economics.
- Badshah, I. U. (2018). Volatility spillover from the Fear Index to developed and emerging markets. *Emerging Markets Finance and Trade*, 54(1), 27–40. doi:10.1080/1540496X.2016.1220294
- Baele, L. (2005). Volatility spillover effects in European equity markets. *Journal of Financial and Quantitative Analysis*, 40(2), 373–401. doi:10.1017/S0022109000002350
- Baele, L., & Inghelbrecht, K. (2009). Time-varying integration and international diversification strategies.

- Journal of Empirical Finance*, 16(3), 368–387. doi:10.1016/j.jempfin.2008.11.001
- Bartram, S. M., & Wang, Y. (2005). Another look at the relationship between cross-market correlation and volatility. *Finance Research Letters*, 2(2), 75–88. doi:10.1016/j.frl.2005.01.002
- Bauwens, L., Laurent, S., & Rombouts, J. V. K. (2006). Multivariate GARCH models: A survey. *Journal of Applied Econometrics*, 21(1), 79–109. doi:10.1002/jae.842
- Begiazi, K., Asteriou, D., & Pilbeam, K. (2016). A multivariate analysis of United States and global real estate investment trusts. *International Economics and Economic Policy*, 13(3), 467–482. doi:10.1007/s10368-016-0349-z
- Beirne, J., Caporale, G. M., Schulze-Ghattas, M., & Spagnolo, N. (2013). Volatility spillovers and contagion from mature to emerging stock markets. *Review of International Economics*, 21(5), 1060–1075. doi:10.2139/ssrn.1340401
- Bekaert, G., Ehrmann, M., Fratzscher, M., & Meh, A. (2014). The global crisis and equity market contagion. *The Journal of Finance*, 69(6), 2597–2649. doi:10.1111/jofi.12203
- Bekaert, G., & Harvey, C. R. (2000). Foreign speculators and emerging equity markets. *The Journal of Finance*, 55(2), 565–613. doi:10.1111/0022-1082.00220
- Bekiros, S. D. (2014). Contagion, decoupling and the spillover effects of the US financial crisis: Evidence from the BRIC markets. *International Review of Financial Analysis*, 33(May), 58–69. doi:10.1016/j.irfa.2013.07.007
- Berger, D., Pukthuanthong, K., & Yang, J. J. (2013). Is the diversification benefit of frontier markets realizable by mean-variance investors? The evidence of investable funds. *The Journal of Portfolio Management*, 39(4), 36–48. doi:10.3905/jpm.2013.39.4.036
- Berndt, E. K., Hall, B. H., Hall, R. E., & Hausman, J. A. (1974). Estimation and inference in nonlinear structural models. *Annals of Economic and Social Measurement*, 3(4), 653–665.
- Boyer, B. H., Kumagai, T., & Yuan, K. (2006). How do crises spread? Evidence from accessible and inaccessible stock indices. *The Journal of Finance*, 61(2), 957–1003. doi:10.1111/j.1540-6261.2006.00860.x
- Brooks, R., & Del Negro, M. (2004). The rise in comovement across national stock markets: Market integration or IT bubble? *Journal of Empirical Finance*, 11(5), 659–680. doi:10.1016/j.jempfin.2003.08.001
- Caporale, G., Pittis, N., & Spagnolo, N. (2006). Volatility transmission and financial crises. *Journal of Economics and Finance*, 30(3), 376–390. doi:10.1007/BF02752742
- Chesnay, F., & Jondeau, E. (2001). Does correlation between stock returns really increase during turbulent periods? *Economic Notes*, 30(1), 53–80. doi:10.1111/1468-0300.00047
- Cornish, E. A., & Fisher, R. A. (1938). Moments and cumulants in the specification of distributions. *Review of the International Statistical Institute*, 5(4), 307–320. doi:10.2307/1400905
- Dooley, M., & Hutchison, M. (2009). Transmission of the U.S. subprime crisis to emerging markets: Evidence on the decoupling–Recoupling hypothesis. *Journal of International Money and Finance*, 28(8), 1331–1349. doi:10.1016/j.jimonfin.2009.08.004
- Driessen, J., & Laeven, L. (2007). International portfolio diversification benefits: Cross-country evidence from a local perspective. *Journal of Banking and Finance*, 31(6), 1693–1712. doi:10.1016/j.jbankfin.2006.11.006
- Engle, R. F., & Kroner, K. F. (1995). Multivariate simultaneous generalized ARCH. *Econometric Theory*, 11(1), 122–150. doi:10.1017/S0266466600009063
- Errunza, V., Hogan, K., & Hung, M. (1999). Can the gains from international diversification be achieved without trading abroad? *The Journal of Finance*, 54(6), 2075–2107. doi:10.1111/0022-1082.00182
- Favre, L., & Galéano, J.-A. (2002). Mean-modified Value-at-Risk optimization with hedge funds. *Journal of Alternative Investments*, 5(2), 21–25. doi:10.3905/jai.2002.319052
- Ghorbel, A., & Boujelbene, Y. (2013). Contagion effect of the oil shock and US financial crisis on the GCC and BRIC countries. *International Journal of Energy Sector Management*, 7(4), 430–447. doi:10.1108/IJESM-04-2012-0002
- Goetzmann, W. N., Li, L., & Rouwenhorst, K. G. (2005). Long-term global market correlations. *The Journal of Business*, 78(1), 1–38. doi:10.3386/w8612
- Guney, Y., Kallinterakis, V., & Komba, G. (2017). Herding in frontier markets: Evidence from African stock exchanges. *Journal of International Financial Markets, Institutions & Money*, 47, 152–175. doi:10.1016/j.intfin.2016.11.001
- Hacihanoglu, E., Simga-Mugan, F. N. C., & Soytaş, U. (2012). Do global risk perceptions play a role in emerging market equity return volatilities? *Emerging Markets Finance and Trade*, 48(4), 67–78. doi:10.2753/REE1540-496X480404
- Hatipoglu, O., & Uyar, O. (2012). Do bubbles spill over? Estimating financial bubbles in emerging markets. *Emerging Markets Finance and Trade*, 48(sup5), 64–75. doi:10.2753/REE1540-496X4805505
- Hung, N. T. (2019). Return and volatility spillover across equity markets between China and Southeast Asian countries. *Journal of Economics, Finance and Administrative Science*, 24(47), 66–81. doi:10.1108/JEFAS-10-2018-0106
- Jarque, C. M., & Bera, A. K. (1980). Efficient tests for normality, homoscedasticity and serial independence of regression residuals. *Economics Letters*, 6(3), 255–259. doi:10.1016/0165-1765(80)90024-5
- Jeon, J. Q., & Moffett, C. M. (2010). Herding by foreign investors and emerging market equity returns: Evidence from Korea. *International Review of Economics and Finance*, 19(4), 698–710. doi:10.1016/j.iref.2010.03.001
- Karolyi, G. A. (1995). A multivariate GARCH model of international transmissions of stock returns and volatility: The case of the United States and Canada. *Journal of Business & Economic Statistics*, 13(1), 11–25. doi:10.2307/1392517
- Kim, B., Kim, H., & Lee, B. (2015). Spillover effects of the U.S. financial crisis on financial markets in emerging Asian countries. *International Review of Economics and Finance*, 39, 192–210. doi:10.1016/j.iref.2015.04.005
- Kim, J. S., & Ryu, D. (2015). Return and volatility spillovers and cojump behavior between the U.S. and Korean stock markets. *Emerging Markets Finance and Trade*, 51(sup1), 3. doi:10.1080/1540496X.2014.998881
- Kim, J. Y., Kim, J., & Kim, S. B. (2010). Transmission of stock prices and volatility from the influential major markets on the emerging market: A case study of the Korean stock market. *Global Economic Review*, 39(3), 247–268. doi:10.1080/1226508X.2010.513139
- Kim, W., & Wei, S. (2002). Foreign portfolio investors before and during a crisis. *Journal of International Economics*, 56(1), 77–96. doi:10.1016/S0022-1996(01)00109-X

- King, M., Sentana, E., & Wadhwani, S. (1994). Volatility and links between national stock markets. *Econometrica*, 62(4), 901–933. doi:10.2307/2951737
- Kizys, R., & Pierdzioch, C. (2009). Changes in the international comovement of stock returns and asymmetric macroeconomic shocks. *Journal of International Financial Markets, Institutions & Money*, 19(2), 289–305. doi:10.1016/j.intfin.2008.01.002
- Knif, J., & Pynnönen, S. (2007). Volatility driven changes in stock return correlation dynamics. *Managerial Finance*, 33(3), 220–235. doi:10.1108/03074350710718293
- Kocaarslan, B., Soytas, U., Sari, R., & Ugurlu, E. (2019). The changing role of financial stress, oil price, and gold price in financial contagion among US and BRIC markets. *International Review of Finance*, 19(3), 541–574. doi:10.1111/irfi.12189
- Li, X., & Zhang, B. (2013). Spillover and cojumps between the US and Chinese stock markets. *Emerging Markets Finance & Trade*, 49(sup2), 23–42. doi:10.2753/REE1540-496X4902S202
- Ljung, G. M., & Box, G. E. P. (1978). On a measure of lack of fit in time series models. *Biometrika*, 65(2), 297–303. doi:10.1093/biomet/65.2.297
- Longin, F., & Solnik, B. (1995). Is the correlation in international equity returns constant: 1960–1990?. *Journal of International Money and Finance*, 14(1), 3–26. doi:10.1016/0261-5606(94)00001-H
- Longin, F., & Solnik, B. (2001). Extreme correlation of international equity markets. *The Journal of Finance*, 56(2), 649–676. doi:10.1111/0022-1082.00340
- Malik, F., & Hammoudeh, S. (2007). Shock and volatility transmission in the oil, US and Gulf equity markets. *International Review of Economics & Finance*, 16(3), 357–368. doi:10.1016/j.iref.2005.05.005
- Melas, D. (2019). The future of emerging markets: 30 years on from the launch of the MSCI emerging markets index. *MSCI research paper*.
- Moon, G., & Yu, W. (2010). Volatility spillovers between the US and China stock markets: Structural break test with symmetric and asymmetric GARCH approaches. *Global Economic Review*, 39(2), 129–149. doi:10.1080/1226508X.2010.483834
- Ng, A. (2000). Volatility spillover effects from Japan and the US to the Pacific-Basin. *Journal of International Money and Finance*, 19(2), 207–233. doi:10.1016/S0261-5606(00)00006-1
- Pätäri, E. J. (2011). Does the risk-adjustment method matter at all in hedge fund rankings? *International Research Journal of Finance and Economics*, 6(75), 69–99.
- Pätäri, E. J., Luukka, P., Fedorova, E., & Garanina, T. (2017). The anatomy of returns from moving average trading rules in the Russian stock market. *Applied Economics Letters*, 24(5), 311–318. doi:10.1080/13504851.2016.1186788
- Pätäri, E. J., & Tolvanen, J. (2009). Chasing performance persistence of hedge funds – Comparative analysis of evaluation techniques. *Journal of Derivatives and Hedge Funds*, 15(3), 223–240. doi:10.1057/jdhf.2009.11
- Patel, S. A., & Sarkar, A. (1998). Crises in developed and emerging stock markets. *Financial Analysts Journal*, 54(6), 50–61. doi:10.2469/faj.v54.n6.2225
- Ramchand, L., & Susmel, R. (1998). Volatility and cross correlation across major stock markets. *Journal of Empirical Finance*, 5(4), 397–416. doi:10.1016/S0927-5398(98)00003-6
- Rujeerapaiboon, N., Kuhn, D., & Wiesemann, W. (2016). Robust growth-optimal portfolios. *Management Science*, 62(7), 2090–2109. doi:10.1287/mnsc.2015.2228
- Saleem, K. (2009). International linkage of the Russian market and the Russian financial crisis: A multivariate GARCH analysis. *Research in International Business and Finance*, 23(3), 243–256. doi:10.1016/j.ribaf.2008.09.003
- Saleem, K., & Vaihekoski, M. (2010). Time-varying global and local sources of market and currency risks in Russian stock market. *International Review of Economics & Finance*, 19(4), 686–697. doi:10.1016/j.iref.2010.03.005
- 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 & Money*, 21(5), 724–742. doi:10.1016/j.intfin.2011.05.001
- Santis, G., & Gerard, B. (1997). International asset pricing and portfolio diversification with time-varying risk. *The Journal of Finance*, 52(5), 1881–1912. doi:10.1111/j.1540-6261.1997.tb02745.x
- Sarno, L., & Taylor, M. P. (1999). Moral hazard, asset price bubbles, capital flows, and the East Asian crisis: The first tests. *Journal of International Money and Finance*, 18(4), 637–657. doi:10.1016/S0261-5606(99)00018-2
- Speidell, L. S. (2011). *Frontier market equity investing: Finding the winners of the future*. Research Foundation of CFA Institute. doi:10.2139/ssrn.2277406
- Speidell, L. S., & Krohne, A. (2007). The case for frontier equity markets. *Journal of Investing*, 16(3), 12–22. doi:10.3905/joi.2007.694758
- Tsay, R. S. (2005). *Analysis of financial time series* (2nd ed.). Hoboken N.J.: John Wiley & Sons.
- Valls, N., & Chuliá, H. (2012). Volatility transmission and correlation analysis between the USA and Asia: The impact of the global financial crisis. *Global Economic Review*, 41(2), 111–129. doi:10.1080/1226508X.2012.686476



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