Data Science in Finance and Economics

DSFE, 2(2): 80–95.
DOI: 10.3934/DSFE.2022004
Received: 19 February 2022
Revised: 29 April 2022
Accepted: 04 May 2022
Published: 12 May 2022

http://www.aimspress.com/journal/dsfe

Research article

Volatility spillovers among MIST stock markets

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Abstract: This paper examines the effects of volatility spillover between MIST stock markets. We used daily data from January 3, 2012, to November 16, 2021, and the test of causality in variance, including structural breaks. First, we observed no structural break for Turkey and Indonesia, but there is a structural break in each South Korean and Mexican stock markets. A structural break is found for Mexico the day, aka "El Betito" was arrested. Likewise, we detected a structural break on the first day of the Covid-19 case for South Korea. We surprisingly observed that Covid-19 did not cause a structural break in these markets during the period analyzed, except in South Korea. GARCH (1,1) models, including structural breaks, show that all series are temporarily and permanently affected by their own shocks. The causality in variance test reveals that MIST countries have volatility spillover effects on each other. There is bidirectional causality in variance between all markets, except South Korea and Mexico. The Mexican stock market is a volatility transmitter for South Korea, but vice versa. The paper indicates a connection in terms of the financial markets of MIST countries, and they are affected by each other's shocks, according to the study results.

Keywords: volatility; spillover; causality in variance; structural break; MIST countries

JEL Codes: D53, G11, G15

1. Introduction

Since the 1990s, the financial markets have become more integrated thanks to globalization, especially in the transmission of financial shocks throughout related markets. Hereby, studying stock market links has become one of the significant fields of financial research. Especially the Asian Crisis, the Brazilian

Currency Crisis, the 2008 Global Financial Crisis, and finally, the Covid-19 Health Crisis show the importance of this integration and its consequences and how volatility spillover across the world.

Many researchers investigate whether there is volatility spillover and which market affects or is affected for different regions and country classifications. For instance, some papers study volatility spillover among developed markets (e.g., Hamao et al., 1990; Moon and Yu, 2010; Wang and Wang, 2010) or between developed and emerging markets (e.g., Kirkulak Uludag and Khurshid, 2019; Ng, 2000; Singh et al., 2010), some studies focus the spillover on the region (Guloglu et al., 2016; Li and Giles, 2015; Majdoub and Sassi, 2017; Verma and Ozuna, 2007).

However, studies examining emerging markets have mostly deliberated on BRICS (or BRIC) countries (Ahmad et al., 2013; Bhar and Nikolova, 2009; Mensi et al., 2017; Panda et al., 2021; Syriopoulos et al., 2015). These countries have organized as a political and economic alliance since 2009, with annual meetings to discuss their economic relations among participating countries (Yarovaya and Lau, 2016). Furthermore, BRICS have an important and systematic role in the global economy because of their economic size, growth rate, and part of international politics, according to Morazán et al. (2012). On the other hand, Dimitriou et al. (2013) cannot observe an alliance in the stock markets of BRICS in their study while Jacobs and Rossem (2014) report that these countries have different strategies for their political, economic, social, and domestic issues and different global power positions, so BRICS cannot be classified as "the rising powers". Furthermore, the BRICS stock markets' volatility spillovers are divergent as both transmitter and receiver in the studies, but there is no consensus (see Ahmad et al., 2013; Gilenko and Fedorova, 2014; Mensi et al., 2017; Yarovaya and Lau, 2016).

The classification of MIST was created more recently and described as the next major emerging markets in 2011, and immediately compared which of these classifications, MIST or BRICS, is more advantageous for international portfolio investors. The MIST countries, which are Mexico, Indonesia, South Korea, and Turkey, unlike the BRICS, do not act as an economic or political alliance (Yarovaya and Lau, 2016). However, MIST countries are expected to have higher growth in the next 20-30 years and can be mentioned as "rising power" together with BRICS, according to Pao et al. (2014). There is a limited number of studies on MIST stock markets in the literature (Kilic and Polat, 2020; Madhavan, 2017; Yarovaya and Lau, 2016; Yavas and Rezayat, 2016), and most of these studies examine the volatility spillover transmission from developed markets except the paper of Kilic and Polat (2020).

This paper aims to examine volatility spillover effects among stock markets of MIST countries using the causality in variance test presented by Hafner and Herwartz (2006). We use daily prices of stock market indices in the study, covering the period of 2012–2021. To our knowledge, this is the first study that analyzes volatility spillovers with causality in variance approach among MIST stock markets. Therefore, we believe that the paper will contribute significantly to the literature. The results show that MIST stock markets are impacted by their own shocks as well as each other. There is bidirectional causality in variance in all markets, except between South Korea and Mexico. Mexico has a volatility spillover effect on South Korea, while there is no vice versa. These results indicate that there are volatility spillovers among MIST countries, and there may be an alliance in terms of financial markets, even if not economic and political.

This article is organized as follows: Section 2 provides a literature review, data and methodology used in the study are given in section 3, empirical results are presented in section 4, and the robustness check is in section 5. The last section includes a discussion of empirical results and the conclusion of the study.

2. Literature review

The literature has emphasized the volatility spillover effect which is the volatility transmission from one country to another. As the volatility spillover is a function of the financial crisis, financial integration, and globalization, several studies have presented significant evidence of volatility spillover across countries and different country groups (Bae and Karolyi, 1994; Karolyi, 1995; Ng, 2000; Singh et al., 2010; Theodossiou and Lee, 1993; Worthington and Higgs, 2004).

For developed countries, one of the early studies provided by Hamao et al. (1990) showed the volatility transmission among three major stock markets. They presented evidence of volatility spillover from New York to Tokyo and London, London to Tokyo, only no spillover effect from Tokyo to London and New York before the 1987 period. Theodossiou and Lee (1993) studied the mean and volatility spillovers effect of the US, the UK, Canada, Japan, and Germany. They provided that there is significant volatility spillover from the US to four stock markets while weak mean spillovers. Moon and Yu (2010) examined the spillover effects of volatilities between US and China stock markets from 1999 to 2007. They detected a structural break in December 2005 and volatility spillover between stock markets symmetrically and asymmetrically before the break. Wang and Wang (2010) investigated mean and volatility spillover among China, US, and Japan stock markets and found evidence for volatility spillover between these markets. Singh et al. (2010) analyzed 15 stock markets across North America, Asia, and Europe and detected that regional volatility spillover is higher among Asian and European markets. Akca and Ozturk (2016) provided evidence of volatility spillovers between six major stock markets, including the US, UK, Germany, Greece, Spain, and Turkey, during the 2008 crisis period. Furthermore, Kirkulak Uludag and Khurshid (2019) investigated whether volatility spillover from China to G7 and E7 stock markets. The findings of their study showed that there is a significant spillover from the Chinese stock market to others, and the greatest volatility spillover exists between China and Japan. Li (2021) employed symmetric and asymmetric volatility spillover across G7 and three emerging stock markets and found that G7 markets are risk transmitters except for Japan when emerging markets are receivers. Trivedi et al. (2021) studied volatility spillovers between European stock markets and showed spillovers exist in Europe except in Poland and Croatia.

For Asia, one of the significant studies presented by Ng (2000) examined volatility spillovers from Japan and US markets to Pacific-Basin markets and showed that both markets are important for this region; however, US market influence is greater. Worthington and Higgs (2004) searched the spillover of volatility in nine Asian markets and separated them into developed and emerging markets. The result of the study indicated that volatility transmission from the developed countries to the emerging countries is not homogeneous, and own volatility spillovers of the emerging markets are higher. Lee (2009) examined the spillover effects of volatility across six Asian stock markets, including India, Hong Kong, South Korea, Japan, Singapore, and Taiwan. The results of the paper showed the existence of significant volatility spillovers on Asian stock markets. Li and Giles (2015) questioned the linkage between the US, Japan, and Asian emerging stock markets and found that volatility spillover effects were strongly bidirectional during the Asian Crisis. Finally, Majdoub and Sassi (2017) investigated volatility spillover between China and six Asian Islamic stock markets between 2011 and 2016. They showed bidirectional volatility transmission across China, Thailand, and Korea.

Most studies included the US stock market as a global factor for Latin American markets when investigating volatility spillover effects. For instance, Verma and Ozuna (2007) searched the volatility spillover from the US to Brazil, Chile, and Mexico and showed no volatility transmission from the US to Brazil. Guloglu et al. (2016) investigated five Latin American stock markets and found that the volatility spillover effect is unidirectional from Brazil to all markets while bidirectional for the Brazil-Mexico pair. Gamba-Santamaria et al. (2017) showed that Brazil is a net volatility transponder for Latin American countries while the spillover effect of the US increased during the 2008 crisis. Similarly, Yousaf and Ahmed (2018) compared the spillover effect in the volatility of the US and Brazil to Mexico, Argentina, Chile, and Peru and found that Brazil has a greater influence on the Latin American stock markets.

Some studies have examined country groups, especially emerging and growing economies. For instance, Korkmaz et al. (2012) provided evidence of weak spillover among CIVETS stock markets. This study showed that Turkey is not a volatility transponder for other countries in the group while Colombia and Indonesia have a spillover effect on Turkey. Furthermore, Ahmad et al. (2013) examined volatility spillover and Eurozone crisis effects of GIPSI stock markets on BRIICKS stock markets. The study showed that Italy, Spain, and Ireland have the highest spillover effects for BRIICKS, whereas Indonesia and Korea are not affected by GIPSI countries. Bhar and Nikolova (2009) showed the spillover effects on the volatility of BRIC countries and found that India has the highest integration with other stock markets in the analysis. On the contrary, the Chinese stock market has a weak spillover effect, indicating international investors' diversification opportunities. Syriopoulos et al. (2015) employed volatility transmission between the US and BRICS countries. Their study showed the significant volatility spillover from the US to BRICS when there was a negative correlation between China and the US. Mensi et al. (2017) examined the volatility spillover between 10 stock markets, including BRICS and developed countries, for the 1997-2013 period. The empirical results indicated that the highest connection is between the US and Brazil despite the paper of Verma and Ozuna (2007) when the lowest spillover is across the US-China and Japan-Brazil pairs. Recently, Panda et al. (2021) investigated the transmission of volatility for 16 stock markets, including developed and BRICS countries, for the 2002–2017 period. The paper found that the US, the UK, and South Africa are volatility transponders while Japan, Brazil, Germany, and Hong Kong are receivers. Akkaya (2021) analyzed the volatility spread for emerging stock markets between 2008-2020. His paper specified that Indonesian and Turkish stock markets have bidirectional volatility spread when volatility on the Indian stock market affects both Indonesia and Turkey. However, the Brazilian stock market has no impact on other markets.

Yarovaya and Lau (2016) studied spillover effects between the UK and BRICS and MIST countries from 2004–2014. The paper showed that all stock markets have a linkage with the UK, except Turkey. Similarly, Yavas and Rezayat (2016) examined the spillover of volatility across the US, BRICS, MIST, and European stock markets. According to this study, Mexico and Indonesia are affected by Russia and Europe and each other when European stock markets are volatility transmitters for Mexico, Indonesia, and South Korea; the US is for Mexico and Turkey. Madhavan (2017) investigated short-run spillovers from five developed stock markets, including the US, UK, Germany, Japan, Singapore, and Hong Kong, to MIST stock markets. The study showed that Mexico is most affected by the US and the least by Japan while Indonesia and South Korea are most affected by Singapore and Hong Kong and the least by the US. Lastly, Kilic and Polat (2020) studied MIST stock markets during the 2004–2019 period. The results indicated a spillover from all markets to Mexico and Turkey and from Mexico and Indonesia to South Korea, just as from Mexico and Turkey to Indonesia.

There are many studies about the volatility spillover effect for different regions and country groups, but limited papers examining MIST countries. Furthermore, these studies examine volatility transmission from developed countries to MIST countries. Therefore, we think that this study, which examines the volatility spillover effect among MIST countries, contributes to the related literature.

3. Data and methods

We examine daily data for the stock markets of MIST countries, including Mexico, Indonesia, South Korea, and Turkey. IPC, IDX, KOSPI, and BIST100 represent the stock market indices of the MIST countries, respectively. We use daily closing prices of the indices from January 3, 2012, to November 16, 2021, collecting 2191 observations for each series. The analysis period started in 2012 to eliminate the effects of the 2008 Financial crisis and the 2011 European debt crisis. In model estimations, daily closing prices are gathered from investing.com and converted to logarithmic return series.

Although numerous papers investigate the causality in variance between markets, two primary methods have been employed in the literature. One of these methods is to estimate multivariate GARCH (MGARCH) models and test the causality in variance by restricting certain parameters. A significant number of studies, on the other hand, critique the MGARCH models since the estimate approach includes several restrictions for parameters to maintain covariance stationarity.

The second method includes estimating a univariate GARCH model that is simpler than the MGARCH models with two alternative testing strategies. One of these is based on the cross-correlation functions of squared standardized residuals generated from the first-staged GARCH model, as proposed by Cheung and Ng (1996) and modified by Hong (2001). However, the test approach of Cheung and Ng (1996) has a significant oversize when the innovations underlying a conditional heteroskedastic process are leptokurtic with small and medium-sized samples Hafner and Herwartz (2006). Moreover, the procedure for testing the cross-correlation function has been criticized in the literature because it may be sensitive to lag and lead order selection. Hafner and Herwartz (2006) suggest a test procedure in which the principle of the Lagrange Multiplier (LM) is noted to investigate the causality in variance and prove that the LM test is more successful relatively Atukeren et al. (2021). The null hypothesis of no causality in variance can be defined as:

$$H_0: Var\left(\varepsilon_{it}\middle|\mathcal{F}_{t-1}^{(j)}\right) = Var\left(\varepsilon_{it}|\mathcal{F}_{t-1}\right), \tag{1}$$

where $\mathcal{F}_t^{(j)} = \mathcal{F}_t \backslash \sigma\left(\varepsilon_{jT}, T \leq t\right)$.

To test H_0:

$$\varepsilon_{it} = \xi_{it}\sqrt{\sigma_{it}^2 g_t}, \qquad g_t = 1 + z_{jt}'\pi, \qquad z_{jt} = \left(\varepsilon_{jt-1}^2, \sigma_{jt-1}^2\right)' \tag{2}$$

where $\sigma_{it}^2 = \omega_i + \alpha_i \varepsilon_{i,t-1^2} + \beta_i \sigma_{i,t-1^2}$.

In Equation 2, a sufficient requirement of Equation 1 is $\pi = 0$, so the null hypothesis of the LM test is $H_0: \pi = 0$ when the alternative hypothesis is $H_A: \pi \neq 0$.

An LM statistic can be generated as follows:

$$\lambda_{LM} = \frac{1}{4T}\left(\sum_{t=1}^{T}(\zeta_{it}^2 - 1)z_{jt}'\right)V(\theta_i)^{-1}\left(\sum_{t=1}^{T}(\zeta_{it}^2 - 1)z_{jt}\right) \xrightarrow{d} x^2, \tag{3}$$

where

$$V(\theta_i) = \frac{\kappa}{4T}\left(\sum_{t=1}^{T} z_{jt}z_{jt}{}' - \sum_{t=1}^{T} z_{jt}x_{it}{}' \left(\sum_{t=1}^{T} x_{it}x_{it}{}'\right)^{-1} \sum_{t=1}^{T} x_{it}z_{jt}{}'\right),$$

$$\kappa = \frac{1}{T}\sum_{t=1}^{T}(\zeta_{it}^2 - 1)^2, \qquad x_{it} = \sigma_{it}^{-2}(\partial\sigma_{it}^2/\partial\theta_i), \quad \theta_i = (\omega_i, \alpha_i, \beta_i)'.$$

The process of Hafner and Herwartz's (2006) the causality in variance test is stated as follows:

1. Estimate a GARCH (1,1) model to specify ε_{it}, ε_{jt} (residuals) and ζ_{it} (standardized residuals), obtain x_{it} (derivatives) and σ_{it}^2 entering z_{jt}. The GARCH (1,1) model suggested by Bollerslev (1986) can be estimated as follows:

$$r_{it} = \mu_{it} + \varepsilon_{it} \qquad (4)$$
$$r_{jt} = \mu_{jt} + \varepsilon_{jt}$$

$$\varepsilon_{i,jt} \backslash (\varepsilon_{i,jt-1}, \varepsilon_{i,jt-2}, \dots, r_{i,jt-1}, r_{i,jt-2}, \dots) \sim GED(0, \sigma_{i,jt}^2)$$
$$\sigma_{it}^2 = \omega + \alpha_i\varepsilon_{it-1}^2 + \beta_i\sigma_{it-1}^2 \qquad (5)$$
$$\sigma_{jt}^2 = \omega + \alpha_j\varepsilon_{jt-1}^2 + \beta_j\sigma_{jt-1}^2$$

Equation 4 is the mean equation of GARCH (1,1) process and r_{it}, r_{jt} are return of the stock markets, μ_{it}, μ_{jt} are the means and ε_{it}, ε_{jt} are error terms. Equation 5 is conditional variance equation, σ_{it}^2 and σ_{jt}^2 are variance of residuals derived from Equation 4.

2. Regress $\zeta_{it}^2 - 1$ on $x_{it}{}'$ and the misspecification indicators in $z_{jt}{}'$.

3. λ_{LM} is T multiplied by the degree of explanation (R^2) of the latter regression.

4. Empirical results

We present the descriptive statistics in Table 1. During the sample period, the daily means of the return series are positive for each country. Turkish stock market which is BIST100 provides the highest mean return but also it is more volatile than other markets according to standard deviation. Besides, Mexico has the lowest mean return and South Korea has the least volatile return series. All return series present strong negative skewness and excess kurtosis. Moreover, the Jarque-Bera (JB) normality test statistics of all series reject the null hypothesis of normal distribution. The Box-Pierce Q statistics show the existence of serial autocorrelations in return and squared return series, and the ARCH-LM test provides that there is an ARCH effect in the return series. Finally, we employ Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests and find that all series are strongly stationary.

Several significant events, both in the MIST countries and the global economy, can be expected to have occurred because the sample of this study is large enough. Therefore, we examine whether there are structural breaks in the variance of series with a modified IT statistic suggested by Sansó et al. (2004). The structural breaks in returns are given in Table 2 and Figure 1. The results of the tests suggest structural breaks in the unconditional variance of Mexico and South Korea stock market returns where one point of sudden change can be identified. On the other hand, we find no evidence of structural breaks in the stock markets of Indonesia and Turkey. On August 8, 2018, the so-called leader of the drug gang, Roberto Moyado Esparza, aka "El Betito", was arrested in Mexico. Figure 1 shows that this case increased volatility in the Mexican stock market significantly and the return decreased by 1.17%. In addition, January 20, 2020, is when the first Covid-19 case was detected in South Korea and caused a return drop of 1.5%. However, we surprisingly found that Covid-19 did not cause a structural break in variance in other return series. The results of the structural break test may be closely related to the sample size. Besides, the volatility process of all stock markets is very similar for this period. Therefore, while no structural break was detected for Turkey and Indonesia, only one break could be seen for Mexico and Korea.

Table 1. Descriptive statistics.

	Mexico	Indonesia	South Korea	Turkey
Mean	0.014380	0.025440	0.022608	0.054258
Median	0.012723	0.086984	0.048533	0.116979
Maximum	4.743942	9.704184	8.251268	6.221721
Minimum	−6.638088	−9.635911	−8.766976	−11.06334
Std. Dev.	1.007525	1.073858	1.003607	1.474787
Skew.	−0.372130	−0.543512	−0.263060	−0.870862
Kurt.	6.724597	12.00403	11.60755	8.393156
JB	1317.023	7509.122	6789.061	2932.264
	(0.000)	(0.000)	(0.000)	(0.000)
Obs	2191	2191	2191	2191
Q(20)	23.7948	19.9967	42.3569	18.5953
	(0.008)	(0.029)	(0.002)	(0.004)
$Q_s(20)$	1602.60	1488.34	2695.57	150.046
	(0.000)	(0.000)	(0.000)	(0.000)
ARCH(5)	91.559	42.3853	276.86	11.760
	(0.000)	(0.000)	(0.000)	(0.000)
ADF	−24.7771*	−14.5805*	−21.2671*	−31.3566*
PP	−46.0090*	−44.4420*	−46.0579*	−47.0516*

Probabilities (p-values) are given in parentheses.

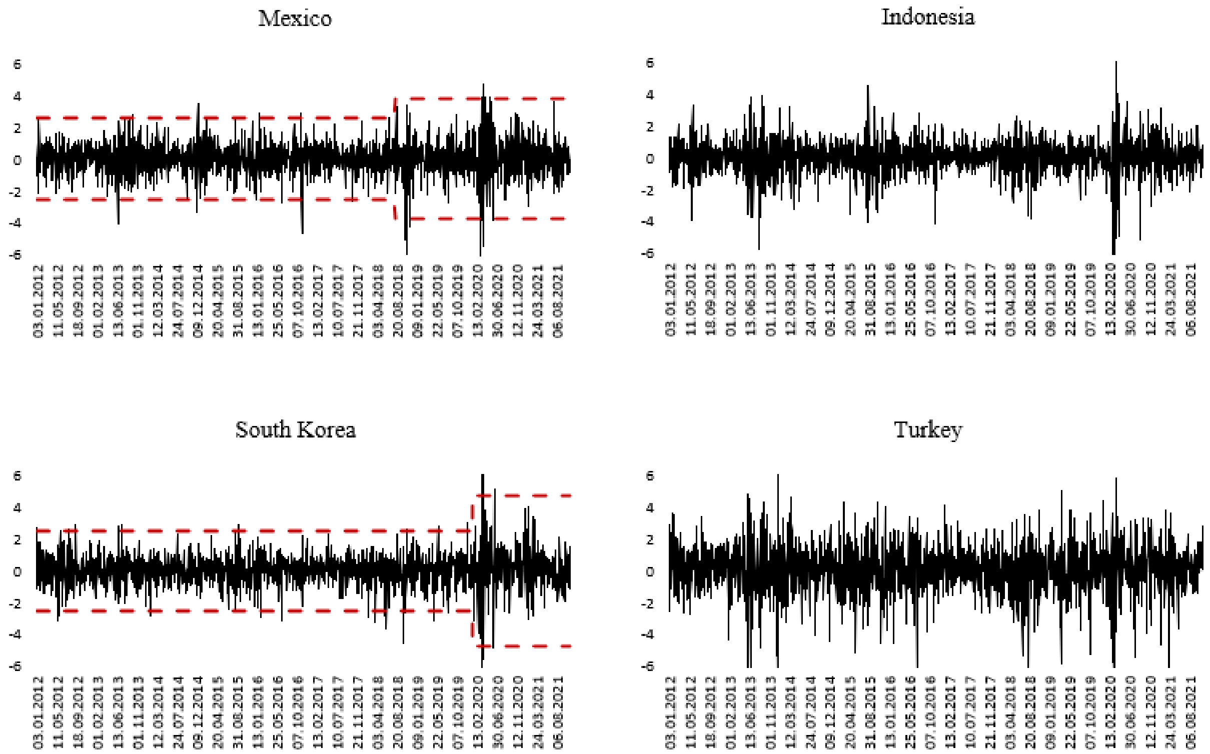
ARCH (5) represents the LM test statistic for the ARCH effect for the 5th lag.

Q (20) and Qs (20) indicate the Box-Pierce serial autocorrelation test statistics for the 20th lag.

* represents stationarity at the 1% significance level.

Table 2. Structural break test in variance.

Mexico	Indonesia	South Korea	Turkey
08.08.2018			
		20.01.2020	



Bands at ±3 standard deviations, change points estimated using modified ICSS algorithm.

Figure 1. Return series with structural breaks.

Table 3. Optimum ARMA structures.

	Mexico	Indonesia	South Korea	Turkey
ARMA	(1,1)	(0,2)	(2,2)	(2,0)

Table 4. Model selection criteria.

Mexico				Indonesia			
	AIC	SIC	HQ		AIC	SIC	HQ
GARCH (1,1)	2.629910	2.653292	2.638456	GARCH (1,1)	2.636953	2.660335	2.645499
GARCH (1,2)	2.630841	2.656821	2.640336	GARCH (1,2)	2.646154	2.662134	2.645649
GARCH (2,1)	2.630284	2.656264	2.639779	GARCH (2,1)	2.645565	2.661544	2.645060
GARCH (2,2)	2.631163	2.659741	2.641608	GARCH (2,2)	2.646419	2.664996	2.646863
South Korea				Turkey			
	AIC	SIC	HQ		AIC	SIC	HQ
GARCH (1,1)	2.535079	2.563657	2.545524	GARCH (1,1)	3.433242	3.457322	3.442486
GARCH (1,2)	2.535136	2.566312	2.546531	GARCH (1,2)	3.433050	3.459030	3.442546
GARCH (2,1)	2.539786	2.566961	2.547180	GARCH (2,1)	3.433940	3.459222	3.442737
GARCH (2,2)	2.540549	2.574322	2.548892	GARCH (2,2)	3.444552	3.467933	3.453097

After detecting structural breaks in the return series, we indicate the optimum ARMA structure (Table 3 and optimum GARCH model (Table 4) for each country according to the AIC information criterion) and estimate GARCH (1,1) models with these results (Table 5). The literature implies that structural breaks in variance cause considerable size distortion in tests of causality in variance, as mentioned above. Therefore, we include dummy variables to adjust for any impact of structural breaks in GARCH models, as in Atukeren et al. (2021), Ewing and Malik (2010), Gemici and Polat (2020), and Nikmanesh and Mohd Nor (2016).

Table 5. GARCH (1,1) model results.

	Mexico	Indonesia	South Korea	Turkey
μ	0.03439**	0.04723*	0.04719*	0.11982*
	(0.050)	(0.003)	(0.006)	(0.000)
AR(1)	−0.61369*		0.86347***	0.00520
	(0.000)		(0.098)	(0.795)
AR(2)			−0.49263	0.02219
			(0.516)	(0.298)
MA(1)	0.64219*	0.00324	−0.84444***	
	(0.000)	(0.895)	(0.096)	
MA(2)		−0.07191*	0.49562	
		(0.003)	(0.517)	
d_m	0.02637***			
	(0.088)			
d_{sk}			0.04854***	
			(0.076)	
ω	0.03880**	0.05074***	0.03016***	0.08897**
	(0.030)	(0.067)	(0.063)	(0.040)
α	0.08802*	0.12849*	0.08061*	0.05136*
	(0.000)	(0.002)	(0.000)	(0.000)
β	0.87993*	0.82370*	0.88779*	0.90685*
	(0.000)	(0.000)	(0.000)	(0.000)
$\alpha + \beta$	0.96795	0.95220	0.96840	0.95821
Log-lik.	−2890.988	−2954.047	−2783.519	−3764.714
Q (20)	14.8875	6.76050	14.9907	16.1741
	(0.670)	(0.080)	(0.525)	(0.580)
Qs (20)	26.1935	7.57161	12.2536	14.0529
	(0.095)	(0.984)	(0.833)	(0.726)

*, ** and *** represents 1%, 5% and 10% significants level, respectively.

We confirm the presence of ARCH effects in all return series based on the results in Table 1; therefore, a GARCH specification is applicable for each series. As a result of model diagnostics, we use the GARCH (1,1) model for properly modeling volatility for all return series under GED distribution. α and β are positive and significant, and their sum is less than 1. Moreover, the Box-Pierce Q statistics indicate that there is no autocorrelation in the variance series. According to Table 5, α and β parameters are statistically significant at the 1% level. Note that α estimates show the persistence of shocks (ARCH factor), while β parameter estimates show the persistence of volatility clusters (GARCH factor). Table 5 shows that the persistence of shocks is higher for Indonesia than other return series, while the persistence of volatility is higher for Turkey. The situation may be due to the more economic and political instability experienced in these countries or their regions. Besides, the Indonesian technology sector has growth potential. Therefore, this sector may cause the shocks in the market to be permanent in general but the volatility to be less permanent. However, when foreign portfolio investors in Turkey withdraw from the market in case of any shock, an atmosphere of panic may occur, and other investors may follow suit. Therefore, the persistence of volatility may be higher. Especially the developments in the country during the research period may cause the results of the analysis to come out in this way. We employ Hafner-Herwartz's (2006) causality in variance test to examine volatility spillover effects between the MIST countries and present results in Table 6. The LM test results show bidirectional causality between all stock markets except the South Korea-Mexico pair; therefore, the null hypothesis of no causality in variance between stock markets can be rejected. On the other hand, there is unidirectional causality from Mexico to South Korea, so the null hypothesis of no causality in variance from South Korea to Mexico is accepted. The effect of volatility in the Mexican stock market on the volatility in the Indonesian stock market is greater than the volatility spillover from Indonesia to Mexico. Therefore, Mexico is a volatility transmitter for Indonesia. While the volatility in the Mexican stock market has a significant impact on the South Korean stock market, the same situation is not valid for South Korea. Indonesia and Turkey are affected by each other's volatility, but the effect of volatility in Indonesia is greater. The exact relationship is valid for South Korea and Turkey. Besides, Indonesia and South Korea transfer volatility to each other at the same rates, while Turkey is a higher volatility transmitter for Mexico.

Table 6. Hafner and Herwatz (2006) causality in variance test results.

MEX → IND	32.915* (0.000)	MEX → TUR	7.086** (0.029)
IND → MEX	5.013*** (0.082)	TUR → MEX	24.931* (0.000)
MEX → KOREA	12.454* (0.002)	IND → KOREA	8.107** (0.017)
KOREA → MEX	3.810 (0.149)	KOREA → IND	7.969** (0.019)
IND → TUR	27.314* (0.000)	KOREA → TUR	22.126* (0.000)
TUR → IND	14.703* (0.001)	TUR → KOREA	18.107* (0.000)

*, **, and *** show a statistically significant causality relation at 1%, 5%, and 10% levels, respectively.

5. Robustness check

One of the most widely used methods in investigating volatility spillover is the Diebold-Yilmaz (DB) Volatility Spillover method modeled by Diebold & Yilmaz (2012). To check the robustness of the causality in variance model, we consider this method for the same series. Our results support the results of the Hafner and Herwartz (2006) causality in variance test.

In Figure 2, the contribution of the volatility in the Mexican, Indonesian, South Korean, and Turkish stock markets to the volatility of other countries is shown in the form of a time graph. The plus sides of the graph indicate that the stock market is a volatility transmitter, and the negative sides indicate that it is a receiver. We can see that Mexico is a volatility transmitter for Indonesia in most periods. Only in the last months of 2018 and mid-2020 Indonesia contributed to the volatility of the Mexican stock market. Although the volatility spillover between Mexico and South Korea continued until 2019, Mexico became the transmitter for the South Korean stock market after 2019. While Turkey was more affected by Indonesia's volatility until the beginning of 2018, this effect decreased after this period and Turkey became a volatility transmitter. However, its volatility's impact is not robust. This relationship is similar between Turkey and South Korea; after 2018, Turkey started to affect the volatility in South Korea more, and this effect is increasing. While Mexico had a greater impact on Turkey's volatility until 2016, Turkey's transmittance has gradually increased since 2017. Finally, the South Korean and Indonesian stock markets have periodically become a transmitter and a receiver for each other.

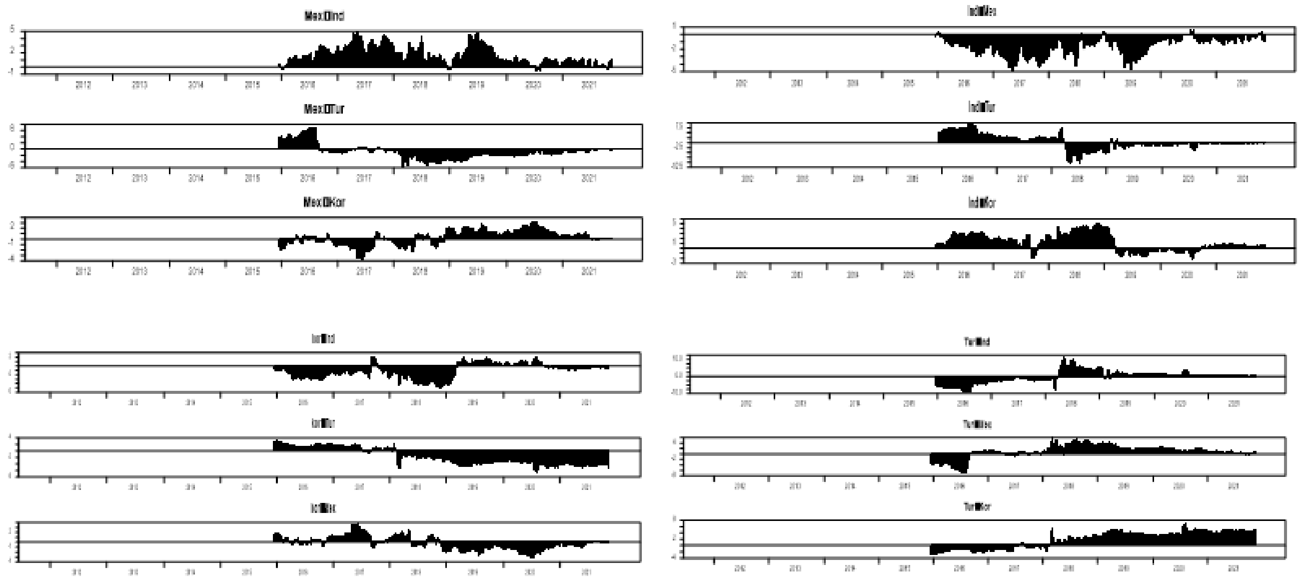


Figure 2. Net pairwise volatility spillovers between MIST stock markets.

6. Discussion

We investigate volatility spillovers in MIST countries with causality in variance test suggested by Hafner and Herwartz (2006) using daily data from January 3, 2012, to November 16, 2021. We use closing prices of IPC, IDX, KOSPI, and BIST100 stock market indices for Mexico, Indonesia, South Korea, and Turkey, respectively. We also consider structural breaks in series and find that there is one structural break in the Mexican and South Korean return series. The structural break was detected for Mexico on August 8, 2018, the date of arrest of the drug gang leader “El Betito”, or Roberta Moyado Esparza. It was determined on January 20, 2020, when the first Covid-19 case was diagnosed for South Korea. However, there is no structural break due to Covid-19 or any social, political, or economic shock. There may be two reasons for this situation: First, the period started from 2012, which is after the Global Financial Crisis, to 2021, with the high number of observations, and second, shocks could have already been priced in the market.

The causality in variance test based on the first-staged GARCH model shows that all markets are affected by their own shocks and volatilities, also each other’s volatilities. There is bidirectional causality in variance relationships among all markets, except Mexico and South Korea. South Korea does not cause the variance of Mexico while Mexico has a volatility spillover effect on South Korea, which is a unidirectional relationship. Moreover, the Diebold-Yilmaz volatility spillover model is applied to check the robustness. Its results support the causality in variance test. The Mexican stock market is a volatility transmitter for Indonesian and South Korean stock markets, but while it was a transmitter for Turkey until 2016, they have shifted since 2017. The Turkish stock market has also become a volatility transmitter for Indonesia and South Korea since 2018, but its effect is not robust for the Indonesian stock market. The volatility in the Indonesian and South Korean stock markets has always affected each other's volatility. These results show that be risk feedback between MIST stock markets. Moreover, they are consistent with the studies of Kilic and Polat (2020), Korkmaz et al. (2012), and Madhavan (2017).

The findings of this study are not only important for investors and policymakers but also contribute significantly to the literature on stock market integration. Further research can improve the paper with different perspectives and methods and consider economic factors or other markets.

7. Conclusions

The study supports that the integration of financial markets has increased following globalization. As a shock occurs in a market also affects other countries. The results are important for investors as well as policymakers to improve strategies. The existence of volatility spillover between MIST countries shows that hedging and diversification opportunities can occur among emerging markets. The analysis results indicate that there was no bidirectional causal relationship in variance between Mexican and South Korean stock markets. For this reason, investors can consider these two markets while diversifying their portfolios because Mexico is a risk transmitter for South Korea and vice versa. In addition, the use of combinations of other MIST markets in the portfolio may cause a decrease in the return or a loss as it will affect the other country when a shock occurs in one country. Thus, investors should consider the effect of stock markets on each other when adding the stocks from both MIST countries and other countries to their portfolios. MIST countries can be accepted as an alternative to BRICS or can be evaluated with these countries for investors. Even if there is no political or economic alliance between MIST countries, they play an important role in the global economy, and it is expected to increase in 20–30 years. However, these countries are different in terms of social, political, economic, and financial structure. At first, South Korea has come to the point of exiting the developing country class. However, its economic growth is not as fast as it used to be and is gradually decreasing. In addition, although Indonesia, as an Asian country, is closer to South Korea in financial markets, it has more common features with Turkey in terms of economy and politics. Both countries have a high youth population, and both are in the category of developing countries with economic and political instability. For this reason, foreign investors generally expect high returns due to high risk when investing in the stock markets of these two countries. In case of any instability, they tend to withdraw from these markets immediately. However, since Indonesia's technology sector has high growth potential, it may have more advantages than Turkey. On the other hand, Mexico is more dependent on the US, both economically and financially. In addition, Mexico can be more affected by the shocks in the Latin American equity markets than the MIST countries. Therefore, when investing in the stock markets of these countries, investors should also consider the volatility spillovers with other countries. The findings are also significant for policymakers. They may consider this situation and act as an alliance with annual summits to discuss their relations to develop their economy and financial markets, like BRICS.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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