Revisiting the Shock and Volatility Transmissions in Asian Equity Markets

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Abstract

The current study looks at how return and volatility spread across stock markets of Asia by applying the Diebold & Yilmaz (2012) spillover index on daily closing values of benchmark indices of Asian stock markets for the period between January 2012 to November 2021 and also considers the impact of the crisis triggered by COVID-19 pandemic. The study uses the prediction error variance decomposition from VAR over a rolling sample for the formation of spillover indices of return and volatility. Our findings reveal that across the research period, similar path is followed by the return and volatility spillover. For the duration of the pandemic crisis, the return spillover and volatility spillover index demonstrate strong integration across Asian stock markets, however, the volatility spillover index shows large bursts throughout the crisis and pandemic period. Furthermore, during the pandemic era, both spillover indices reached their peak, highlighting the severity of the pandemic. Thus, our results show that spillover connectedness has dynamic and volatile features for returns and volatility series for the chosen markets. It has also been noted that Hong Kong and Indonesian stock markets are net contributors whereas the stock markets of Japan, South Korea, Malaysia, Philippines, Taiwan, China, and India are the net recipients of return spillover.

Keywords: Return, Volatility Spillover Index, Asian Stock Markets, Pandemic, Contagion, Economic Turbulence.

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1. INTRODUCTION

In recent decades, technological breakthroughs and financial deregulations, as well as advancements in telecommunications, information systems, and computer technology have led to an increase in global trade. This has further expanded cross-market connectivity in international financial markets, notably stock markets(Badshah et al., 2018). The dynamic interconnection of cross-markets has an impact on asset allocation and management and transmission of risk in primary and secondary markets. For investors and governments, the increased interconnectedness of international financial markets has been critical. When financial contagion becomes a widespread occurrence, information transfers throughout stock markets are critical for individual investors, portfolio managers, other market players, and regulators (Yousaf et al., 2020). If the stock markets are influenced by the volatility and return spillover from overseas markets, the goal of portfolio diversification is undermined (Diebold & Yilmaz, 2009; Arouri, et al., 2011; Balli, et al, 2021). Therefore, it becomes important for portfolio managers to identify the market which remains unaffected by the developments at the global level to provide diversification to their portfolio (Baele, 2005; Engle et al., 2012; Seth& Sharma, 2015; Neaime, 2016). Return and volatility spillover among the equity markets has been empirically examined by many researchers throughout Asia's 1997 financial crisis (Wu 2005; Nam et al. 2008; Choi et al. 2009; Yilmaz, 2010), global financial crisis of 2008 (Yilmaz, 2010; Singhania & Anchalia, 2013;Hwang, 2014; Li & Giles, 2015; Bajo-Rubio et al, 2017; Kumar & Khanna, 2018) and stock market crash in China in 2015 (Xiong et al., 2018; Yousaf & Hassan 2019). However, the literature on linkages between the Asian equity markets for the COVID-19 pandemic is still evolving. The pandemic which has affected nearly the entire globe has raised some serious concerns about the susceptibility and precariousness of equity markets to the global crisis which can quickly emerge and spread globally. During the initial phase of the pandemic worldwide insecurity, economic slowdown, and, severe depression has been detected. The situation has improved to an extent lately but given the pace at which cases rose in Europe (November 2017) again despite the double vaccination of nearly two-thirds of their population, the situation became critical again which led to fears of worldwide recession.

The COVID-19 pandemic is once in life kind of phenomenon which presents a unique opportunity to examine important questions:

1. How do return and volatility spillover behave during crisis periods and pandemics?
2. How does it pose threat to portfolio diversification for the investors?

The present study considers only the prominent Asian economies which have over 10-20 years have emerged as global powerhouse and have continuously been growing at a rate greater than the world average growth rate and are pivotal to the growth of the overall world economy. The present study investigates the cointegration between the region's equity markets and studies the consequences of the different crises and the COVID pandemic on select stock markets of Asia.

The variance decomposition analysis and the VAR model have been applied on a rolling window of 100 days of return and volatility values for each of the markets. The contribution of market spillover to the variance of forecast errors has been estimated for each rolling window. A measure of spillover across these markets has been obtained by plotting the cumulative contribution values of return and volatility spillover in all the markets across time. In various ways, our methodology departs from some of the mentionable empirical studies in the area of financial contagion (Milunovich & Thorp, 2006; Chow, 2017; Roni et al, 2018). Our study does not look for the presence of financial contagion before or after a crisis as the dates for the start and finish of crises during the study period have been identified exogenously. Instead, by charting the return and volatility spillover indices, we can explain variation in the spillover independently with the help of the rolling window approach.

The findings of our research show that both volatility spillover and return amongst Asian markets trend in the same direction over time. Both the spillover indices of return and volatility series explicitly indicate a surge in the financial connectedness among the Asian markets besides this volatility spillover index also shows a considerable burst for the COVID-19 pandemic period. Both volatility and return spillover indices attained their corresponding tops during the COVID-19 period which reflects the severity of this crisis.

The rest of this paper is presented as follows. The literature on financial market dynamics is reviewed in Section 2. The spillover index technique is explained in Section 3 of our study. The findings of the spillover index technique during the crisis periods and the COVID-19 period are shown in Section 4. Section 5 concludes the study with important implications and the future scope of the study.

2. REVIEW OF LITERATURE

Several earlier studies have focused on the dynamics of financial markets, specifically concerning the crisis. (Yang et al, 2003; Kenourgios et al, 2011; Gulzar et al, 2019; Sadiq et al, 2021; Jebabli et al., 2022). During crisis times, a few scholars have looked at the linkages that are dynamic between financial markets. As a result, we categorize known research according to when the crisis occurred.

Starting from the Asian currency crisis of 1997 some researchers look into the interconnections between financial markets. The breakdown in the foreign currency (FX) markets triggered the crisis, various researchers have looked at the causes, consequences, and dynamic links between cross-border financial markets. (Noble & Ravenhill, 2000; Thangavelu et.al., 2009) During the crisis, the links between Asian stock markets were also studied. (Jang & Sul, 2002; Click & Plummer, 2005; Khan & Park, 2009). During the year 1998, there was a lot of turmoil in the global financial markets, according to the researchers. The Russian crisis had significant international contagion implications. (Fry et. al., 2002; Saleem, 2009; Sojli, 2007). The Argentinean crisis of 1998 originated in Argentina and was caused due to Exchange Rate and Fiscal Deficit its effect was regional and there was no contagion effect. (Boschi, 2005; Dapontas, 2014). The dot-com bubble was a stock market bubble that burst in the United States in 2000 due to excessive financial speculation in Internet-related businesses. It had a big impact on the stock markets in the United States and Europe. (Kraay & Ventura, 2005). The Global Financial Crisis of 2007, which initiated in the United States, caused such devastation to the global economy that much research has been done on the ever-changing connections between nations and various financial asset markets. The stock market was largely used to investigate dynamic inter-country relations. This is because dynamic links between financial assets such as stocks, bonds, currencies, commodities, and many more were investigated. Finally, throughout the Great Recession, the ties that bind nations and economic sectors changed and intensify over time. (Edey, 2009; Moshirian, 2011; Karfakis & Panagiotidis, 2015; Kumar & Khanna 2018; Khanna & Kumar 2019; Kumar & Khanna 2020) The sovereign debt problem in Europe. Various financial concerns, including the collapse of financial institutions and excessive governance debt, happened during the European debt crisis from 2009 to 2012. As a result, during the crisis, various researchers, scholars, and academicians looked at the dynamic linkages across European financial systems, such as dynamic connectedness in stock markets. (Tamakoshi & Hamori, 2015; Baruník et al., 2017; Jebabli et al., 2022). Finally, while the latest COVID-19 epidemic was sparked by health concerns, it has already wreaked havoc on the global economy. As a result, various studies, similar to those conducted during the Great Recession, look into the dynamic interconnections between countries and financial assets. (Tamakoshi & Hamori, 2013; Zhang et al, 2020; Ali, M. et al. 2020; Naeem et al, 2021; Zhao et al, 2022).

This paper adds to the existing intellectual structure about the dynamic ties that exist between Asian countries. We investigate the dynamic interconnectedness of volatility shocks across time and during the COVID-19 pandemic. The outbreak has had a significant impact on the global financial system when compared to different crises. Furthermore, we add to the literature by elucidating the impact of the different crises from 2012 to 2021 on their connection. Our data-based results and analysis are important and valuable to users and stakeholders in Asian stock markets.

3. METHODOLOGY

For analyzing the spillover of return and volatility across the select stock markets, we have employed the approach of the spillover index established by Diebold & Yilmaz (2009a) . An N-variable model of vector autoregression is used to simulate the returns and volatilities of stock markets. We sum the shares of its prediction error variation owing to shocks in

other stock markets j, for all j #i i for each market i. The spillover index is then calculated by adding all i = 1,..., N. The method for calculating the spillover index is described below.

$$x_t = \sum_{i=1}^{p} \theta_i x_{t-i} + \varepsilon_t \quad (1)$$

Let's take a closer look at how the spillover index is calculated. Consider the pth-order N-variable VAR with stationary covariance expressed as:

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} \quad (2)$$

where the NxN coefficient matrices A_i confirm the recursion $A_i =$

$$x_t = \sum_{i=0}^{\infty}(A_i P)(P^{-1}\varepsilon_{t-i}) = \sum_{i=0}^{\infty}(A_i P)(\tilde{\varepsilon}_{t-i}) = \sum_{i=0}^{\infty}\tilde{A}_i\tilde{\varepsilon}_{t-i} \quad (3)$$

such that $\tilde{\varepsilon}_t = P^{-1}\varepsilon_t$ are orthogonalized, with a mean value equal to zero and an identity covariance matrix. The prediction error variance of each variable can be divided into two fractions namely, shocks from own sources and shocks from exogenous sources by applying the variance decomposition technique.

The breakdown of the matrix of covariance of the forecast errors is stated as:

$$\theta_{ij}(H) = \frac{\sum_{h=0}^{H-1}(e_i' A_h P e_j)^2}{\sum_{h=0}^{H-1}(e_i' A_h \Sigma A_h' e_i)} = \frac{\sum_{h=0}^{H-1}(e_i' \tilde{A}_h P e_j)^2}{\sum_{h=0}^{H-1}(e_i' \tilde{A}_h \Sigma \tilde{A}_h' e_i)} \quad (4)$$

where e_i is an Nx1 matrix with elements equal zero $\theta_{ij}(H)$ shows the shock of standard-deviation of one in jtn market to the variance of the H-step ahead prediction error of ith market, shown as

$$\sum_{j=1}^{N}\theta_{ij}(H) = 1 \text{ and } \sum_{i,j=1}^{N}\theta_{ij}(H) = \text{N.}$$

After obtaining the spillover measures from ith market to jth market for all i and j, spillover index can be defined in percentage terms as given below:

$$S(H) = \frac{\sum_{i,j=1,i\neq j}^{N}\theta_{ij}(H)}{\sum_{i,j=1}^{N}\theta_{ij}(H)} X\ 100 = \frac{\sum_{i,j=1,i\neq j}^{N}\theta_{ij}(H)}{N} X\ 100 \quad (5)$$

The spillover index in the VAR structure is the total aggregate of the matrix's off-diagonal elements produced from the variance decomposition procedure. The total number of variables divided by the sum of the diagonal components aids in determining the own shocks. This segmentation of variation has ramifications for both investors' portfolios and regulators' policy formation.

4. DATA ANALYSIS AND INTERPRETATION

4.1 Data

From January 2012 to September 2021, we looked at stock market index performance for nine stock markets of Asia namely; Hongkong (HK), Indonesia (JKSE), Japan (NIK), South Korea (KOSPI), Malaysia (KLSE), Philippines (PSEI), Taiwan (TSEC), China (SCI), and India (NSE). The daily continuous return has been computed using the daily closing levels of the benchmark indices chosen where $r_{it} = \Delta \ln P_{it} * 100$ for market i at the time 't'. The daily return volatilities have been estimated using the daily low, high, closing, and opening price values for each day by using the Garman and Klass (1980) method wherein daily variance is given as follows:

$$\sigma_{it}^2 = 0.511\,(H_{it} - L_{it})^2 - 0.019\,[(H_{it} + L_{it} - 2O_{it}) - 2(H_{it} - O_{it})(L_{it} - O_{it})] - 0.383(C_{it} - O_{it})^2 \quad (6)$$

where C, O, H, L are the natural logarithm of daily Close, Open, High, and Low prices respectively.

The descriptive statistics for returns and volatilities of all 9 Asian markets are presented respectively in Table 1 and Table 2.

Table 1: Descriptive Statistics of Stock Markets Returns

	rhsi	rjkse	rnik	rkospi	rklse	rpsei	Rtsec	rsci	Rnse
Mean	0.0058	0.0146	0.0552	0.0325	-0.0005	0.0015	0.0520	0.0125	0.0643
Median	0.0475	0.0783	0.0703	0.0522	0.0190	0.0417	0.0766	0.0443	0.0962
Maximum	6.9869	9.7042	7.4262	8.2513	4.2961	7.1717	5.0302	6.3691	8.4003
Minimum	-6.0183	-6.8051	-8.2529	-8.7670	-5.4047	-14.3224	-6.5206	-8.8732	-13.9038
Std. Dev.	1.1530	1.0828	1.3591	0.9776	0.6749	1.2936	0.9496	1.3503	1.1079
Skewness	-0.2857	-0.2422	-0.2578	-0.5118	-0.7189	-1.5745	-0.7358	-0.9773	-1.7037
Kurtosis	5.9266	11.1100	7.2500	13.1875	10.6773	19.0027	9.1774	10.9733	24.2171
Jarque-Bera	644.64	4785.47	1328.84	7600.41	4423.10	19285.13	2923.63	4886.11	33478.92
Observations	1740	1740	1740	1740	1740	1740	1740	1740	1740

Source: Authors' calculations

Note: Rhsi (Return on Hang Seng Index), rjkse (Return on Jakarta Stock Exchange), rnik (Return on Tokyo Stock Exchange), rkospi (Return on Korea Composite Stock Price Index), rklse (Return on Kuala Lumpur Stock Exchange), rpsei (Return on Philippines Stock Exchange), rtsec (Return on Taiwan Stock Exchange), rsci (Return on Shanghai Composite Index), rnse (Return on National Stock Exchange)

Table 2: Descriptive Statistics of Volatilities of Stock Markets Returns

	varhsi	varjkse	varnik	varkospi	varklse	varpsei	Vartsec	varsci	varnse
Mean	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0002	0.0001
Median	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
Maximum	0.0044	0.0029	0.0041	0.0049	0.0011	0.0173	0.0022	0.0095	0.0257
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	0.0002	0.0002	0.0002	0.0002	0.0001	0.0005	0.0001	0.0005	0.0007
Skewness	11.2186	9.1866	8.1411	13.6378	7.4466	28.5330	8.8164	8.6076	31.4819
Kurtosis	199.4260	113.8775	92.5651	286.0658	84.3619	940.0233	125.2423	102.3833	1146.2030
Jarque-Bera	2833780*	915777*	600809*	5863089*	496014*	63892016*	1105922*	737572*	95038683*
Observations	1740	1740	1740	1740	1740	1740	1740	1740	1740

Source: Authors' calculations, * significant at 1% level of significance

Note: varhsi (Variance Hang Seng Index), varjkse (Variance Jakarta Stock Exchange), varnik (Variance Tokyo Stock Exchange), varkospi (Variance Korea Composite Stock Price Index), varklse (Variance Kuala Lumpur Stock Exchange), varpsei (Variance Philippines Stock Exchange), vartsec (Variance Taiwan Stock Exchange), varsci (Variance Shanghai Composite Index), varnse (Variance National Stock Exchange)

4.2. Spillover Indices of Return and Volatility Spillover

Our study employs VAR with lag length (p = 2) for a 10-step forward predictions (h = 10) on a total of (N = 9) equity markets. The re-estimate of the VAR with a 100-days rolling estimation window captures the concept of temporal variation in spillovers. The spillover indices have been estimated and plotted after ensuring the covariance stationarity of the parameters in VAR.

Table 3: Spillover of Return among the Asian Countries

	rhsi	rjkse	rnik	Rkospi	Rklse	rpsei	rtsec	rsci	rnse	From others
rhsi	98.5	0.2	0.1	0.1	0.3	0.0	0.0	0.6	0.1	1.5
rjkse	19.4	77.9	0.5	1.0	0.3	0.2	0.1	0.5	0.2	22.1
rnik	25.8	1.2	71.4	0.5	0.0	0.0	0.2	0.3	0.5	28.6
rkospi	39.6	5.0	6.5	48.1	0.1	0.3	0.1	0.3	0.1	51.9
rklse	22.2	9.2	2.2	1.5	64.4	0.1	0.1	0.3	0.1	35.6
rpsei	16.2	14.6	1.3	1.7	3.6	61.3	0.4	0.1	0.8	38.7
rtsec	38.9	4.7	4.3	7.7	0.7	0.2	43.0	0.4	0.1	57.0
rsci	33.5	0.1	0.1	0.3	0.3	0.0	0.2	65.5	0.1	34.5
rnse	23.4	7.0	1.1	2.4	0.9	0.8	0.2	0.6	63.6	36.4
Contribution to others	219.1	41.9	16.1	15.1	6.2	1.6	1.3	3.2	1.9	306.4
Contribution including own	317.6	119.8	87.5	63.1	70.6	62.9	44.3	68.7	65.5	Index=34.04%
Net Spillover	217.6	19.8	-12.5	-36.9	-29.4	-37.1	-55.7	-31.3	-34.5	

Source: Authors' calculations. Note: Order of VAR for variance decomposition is identified with the help of Cholesky factorization.

Note: Rhsi (Return on Hang Seng Index), rjkse (Return on Jakarta Stock Exchange), rnik (Return on Tokyo Stock Exchange), rkospi (Return on Korea Composite Stock Price Index), rklse (Return on Kuala Lumpur Stock Exchange), rpsei (Return on Philippines Stock Exchange), rtsec (Return on Taiwan Stock Exchange), rsci (Return on Shanghai Composite Index), rnse (Return on National Stock Exchange)

Table 4: Spillover of Volatility among the Asian Countries

	Varhsi	varjkse	varnik	Varkospi	varklse	varpsei	Vartsec	varsci	varnse	From others
varhsi	86.2	1.3	0.8	3.9	0.7	1.9	1.7	3.0	0.5	13.8
varjkse	1.4	75.3	0.8	14.0	0.8	5.4	0.6	0.1	1.7	24.7
varnik	13.2	6.2	73.6	4.3	0.1	0.2	1.5	0.1	0.7	26.4
varkospi	6.0	19.6	4.4	63.3	1.2	2.3	0.2	0.1	3.0	36.7
varklse	3.3	5.8	2.7	9.7	72.7	1.0	2.5	0.1	2.2	27.3

varpsei	1.9	16.1	4.5	24.7	0.4	49.7	0.1	0.0	2.6	50.3
vartsec	6.5	9.3	5.1	25.6	0.6	1.2	49.7	0.7	1.3	50.3
varsci	6.7	0.1	0.6	0.2	1.0	0.1	3.6	87.4	0.3	12.6
varnse	1.1	18.0	4.8	37.2	0.9	15.9	0.2	0.1	21.8	78.2
Contribution to others	40.0	76.3	23.8	119.6	5.7	28.1	10.4	4.1	12.3	320.3
Contribution including own	126.2	151.6	97.4	182.8	78.4	77.8	60.1	91.5	34.0	Index=35.59%
Net Spillover	26.2	51.6	-2.6	82.8	-21.6	-22.2	-39.9	-8.5	-66.0	

Source: Authors' calculations. Note: Order of VAR for variance decomposition is identified with the help of Cholesky factorization

Note: varhsi (Variance Hang Seng Index), varjkse (Variance Jakarta Stock Exchange), varnik (Variance Tokyo Stock Exchange), varkospi (Variance Korea Composite Stock Price Index), varklse (Variance Kuala Lumpur Stock Exchange), varpsei (Variance Philippines Stock Exchange), vartsec (Variance Taiwan Stock Exchange), varsci (Variance Shanghai Composite Index), varnse (Variance National Stock Exchange)

Figure 1: Asian Market Return Spillovers

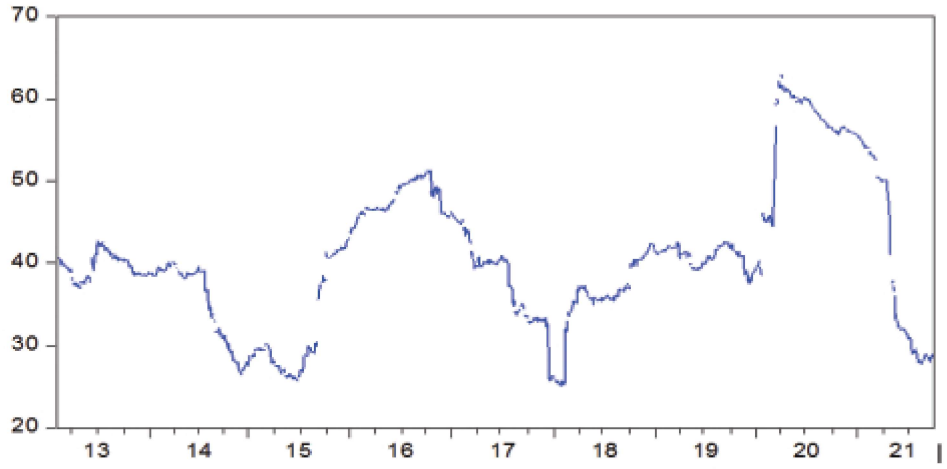
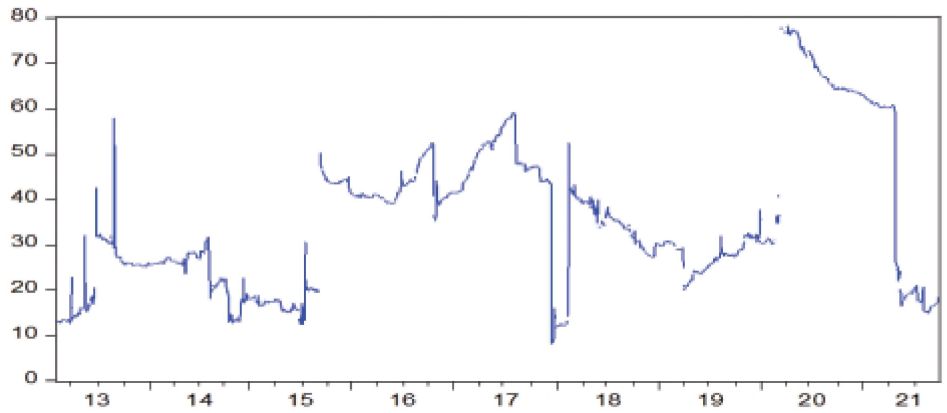


Figure 2: Asian Markets Volatility Spillovers



4.3 Asian Markets Spillover

Return and volatility spillover indices computed for the entire study period have been presented in Table 3 and 4 respectively providing a clear understanding of how these indices have been constructed. The variance decompositions have been computed with the help of Cholesky factorization-based variance decompositions and the order of the stock markets is as given in these Tables. The results of return spillover (see Table 3) show that spillover coming from other markets is 1.5% in the case of Hongkong and it goes up to 57% in the case of Taiwan. The contributions of Hongkong to other markets total 219 points, and that of the Indonesian market is relatively very small (41.9 points) which further goes on falling for the countries which are ordered afterward. By summing the elements in the "Contribution to Others" row (or the "Contributions from Others" column), we may derive the index of spillover: Market spillover accounts for 34% of the total 900 points of prediction error variation across all 9 markets. Own shocks account for the remaining 66% of overall forecast error variation. Table 4 shows that the index of volatility spillover is only marginally higher than the return spillover index for the whole study period, with a value of 35.59% which means that return volatility shocks propagate across the region's equity markets a little quicker than return spillover. The computations provided in the Tables 3&4 provide average spillover for returns and volatility throughout the whole sample.

For understanding the movement of the return and volatility spillover we have produced the measures of spillover indices over a rolling window of 100 days. Figures 1 and 2 show return and return volatilities overflow charts, respectively. In 2013, nearly 40% of stock index return shocks spilled over to other markets. Following the United States debt-ceiling crisis, which began in January 2013 and lasted until October 2013, return spillover climbed slightly to 41% to 42% and remained around 40% for the year 2013. Return spillover fell to 25% in March 2014 after the debt-ceiling issue. In 2015 the stock market turmoil of China started with the exploding stock market fizz. Global stock markets were facing steep fall by early 2016. Anxiety selling was caused by negative economic data from China. Rates of interests plunged, instigating prevalent fears of deflation and depression during this period. In addition to this economy in the United States was so sluggish that enormous historically dependable indications of the impending recession were raising caution lights. The world economy deteriorated much more as a result return spillover amplified swiftly to 50% band. By mid-2017 return spillovers declined to 25% after which spillover remained in a range between 35-40% for nearly 2 years. After 2 years of variation in a range of 30–40%, the spillover index hopped to an important level of 60% in January 2020 which corresponds to the inception of the COVID-19 pandemic. It reached to 50% level by April 2021 and reached 30% by September 2021.

The volatility spillover movement is presented in Figure 2. A look at the movement of index of volatility spillover values over the study period clearly shows that the movement of index of volatility spillover is sharper than the movement of index of return spillover which is relatively steady. During the debt-ceiling crisis, the volatility spillover plot saw the biggest surge. Following a significant policy failure in the United States, the index of volatility spillover soared to nearly 60% in the early part of 2013. Subsequently, the index of volatility spillover settled nearly to 25% band for almost a year and reached a minimum of 12% by mid of 2014. In the second half of 2014, Brazil experienced a severe economic crisis and this led to fluctuations in volatility spillover in Asian stock markets also. In addition to this Chinese stock market turbulence began in 2015 as a result Asian volatility spillover soared beyond 50%. The volatility spillover index fluctuated between 35% and 60% until the beginning of 2017. During this phase first major fall was seen in Brazilian markets which gradually expanded to China in June 2015 and later on transgressed to other Asian countries by the end of the year 2016. The volatility spillover index started declining in 2017 and reached nearly to a level of 10 percent by July 2017 before rising again in the last quarter of the year 2017 which also saw the Dow Jones Industrial Average, S&P 500, losing nearly 10% of their values

since the beginning of the year. For this period a loss of over $7 trillion has been observed in the world markets, it also saw a fall in developing markets triggered by a rise in the dollar. The spread of this volatility was so expansive that it did not even spare gold and US government bonds which too lost values in this period. The volatility spillover index increased for Asian stock markets and reached more than 55% due to market tensions. After a favourable economic environment in the year 2018 which saw a large number of firms hitting the market with initial public offerings (IPOs) and making most of the investors' faith in the market, the volatility spillover index started falling again. The global stock market changed in numerous ways as a result of this development: Pension funds, mutual funds, and other intermediaries helped households outside of Asia grow their investments in Asian enterprises. Furthermore, the majority of publicly traded corporations were controlled by the government or other private companies, and smaller Asian growth enterprises used capital markets to obtain money more frequently than smaller companies from other parts of the world. The volatility spillover index increased briefly in 2019 and peaked by the end of 2019. The shock to the Asian stock markets from COVID-19 was faster and more severe. Markets became volatile as a result of a significant jump in the index due to pandemic. During 2020, the volatility spillover index started to decline and reached a level of 60% from 80%. This level was still higher when compared to previous crisis periods. In nutshell, it may be ascertained that transmission of volatility spillover has been more dynamic during the COVID-19 pandemic vis-à-vis periods of the financial crisis. This highlights the greater impact of the pandemic in comparison to financial shocks on the relationship between Asian stock markets for the period under review. By end of 2020 volatility spillover index in the majority of stock markets reached its minimum level of 15 percent. The fear that erupted when COVID-19 was labelled a pandemic in March 2020 has been exuberantly recovered by equity markets as the economies worldwide were swift in announcing sizeable fiscal stimulus packages opted for accommodative monetary policy measures to support the economy. The recovery has been led by cyclical companies, which have been boosted by optimism about the delivery of vaccinations and new rounds of fiscal stimulus in key economies. On the back of these positive developments, crude oil and other commodity prices firmed up, with production restraints by the Organization of Petroleum Exporting Countries providing added momentum in February and March 2021, laying the groundwork for the formation of a new commodity super-cycle. During 2020 and 2021, monetary and credit circumstances remained expansionary, and financial market conditions significantly improved. As a result, volatility Spillover index fluctuations in 2021 ranged from 15% to 20%. Thus, there are clear indications that the volatility and return spillover index shows big bursts during crises that may have a short or long-term impact on equity markets.

One of the important limitations of the Cholesky factorization method for variance decomposition is that it is very sensitive to market orders. Therefore, it is very important to analyze the sensitivity of the spillover index to the ordering of chosen markets. Unfortunately, because our research includes nine markets, we are unable to calculate the spillover index for all feasible (which totals 9!) market orderings. Instead, we take into account just 9 market rotations. To begin, we calculate the spillover index using the original market ordering shown in Tables 3 and 4.After which the first market was moved to the last place and Indonesia became the first market. This process was repeated till the last of the market in the original order came to the first place. For all the 9 orderings we computed the median, minimum, and maximum values for both types of spillover indices and presented their plots in Figures 3 and 4 respectively. Further, descriptive statistics of the return and volatility spillover indices are presented in Tables 5 & 6. The return and volatility spillover indices, regardless of the order, follow the same path as in the initial ordering which confirms the notion that both the indices remained unaffected by the sequence of the markets.

Table 5: Descriptive Statistics of 9 Rotated Return Spillover Indices

	rhsi	rjkse	rnik	rkospi	rklse	rpsei	rtsec	rsci	rnse
Mean	40.590	39.816	40.117	40.043	39.896	40.039	39.979	39.884	40.539
Median	40.003	39.165	39.528	39.647	39.710	39.815	39.837	39.451	39.973
Maximum	62.912	62.649	62.586	62.942	61.879	63.008	61.869	61.310	63.060
Minimum	25.102	24.067	24.179	24.198	24.589	24.365	24.647	24.994	25.178
Std. Dev.	8.617	8.469	8.467	8.499	8.373	8.533	8.354	8.320	8.635
Skewness	0.469	0.554	0.503	0.543	0.416	0.463	0.403	0.430	0.479
Kurtosis	2.867	3.015	2.920	3.012	2.875	2.984	2.878	2.811	2.868
Jarque-Bera	57.494	78.658	65.203	75.688	45.441	54.937	42.535	49.705	60.025
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	1539	1539	1539	1539	1539	1539	1539	1539	1539

Source: Authors' calculations

Note: Rhsi (Return on Hang Seng Index), rjkse (Return on Jakarta Stock Exchange), rnik (Return on Tokyo Stock Exchange), rkospi (Return on Korea Composite Stock Price Index), rklse (Return on Kuala Lumpur Stock Exchange), rpsei (Return on Philippines Stock Exchange), rtsec (Return on Taiwan Stock Exchange), rsci (Return on Shanghai Composite Index), rnse (Return on National Stock Exchange)

Table 6: Descriptive Statistics of 9 Rotated Volatility Spillover Indices

	varhsi	varjkse	varnik	varkospi	varklse	varpsei	vartsec	varsci	varnse
Mean	35.513	35.768	35.802	35.757	35.032	35.156	35.077	34.799	34.947
Median	31.369	31.464	31.816	31.838	32.024	31.936	31.664	31.384	31.209
Max.	78.191	77.407	77.143	76.677	73.829	74.609	74.906	75.052	76.223
Min.	8.272	8.152	8.205	8.211	8.228	8.235	8.213	8.237	8.172
Std. Dev.	16.192	16.347	16.266	15.919	14.951	15.155	15.24	14.98	15.31
Skewness	0.646	0.597	0.563	0.513	0.457	0.480	0.486	0.498	0.546
Kurtosis	2.653	2.538	2.463	2.439	2.441	2.449	2.419	2.424	2.502
Jarque-Bera	113.33	103.987	98.546	86.772	72.783	77.726	81.38	83.97	91.35
Observations	1521	1521	1521	1521	1521	1521	1521	1521	1521

Source: Authors' calculations

Note: varhsi (Variance Hang Seng Index), varjkse (Variance Jakarta Stock Exchange), varnik (Variance Tokyo Stock Exchange), varkospi (Variance Korea Composite Stock Price Index), varklse (Variance Kuala Lumpur Stock Exchange), varpsei (Variance Philippines Stock Exchange), vartsec (Variance Taiwan Stock Exchange), varsci (Variance Shanghai Composite Index), varnse (Variance National Stock Exchange)

Figure 3: Return Spillovers in 9 Asian Stock Markets

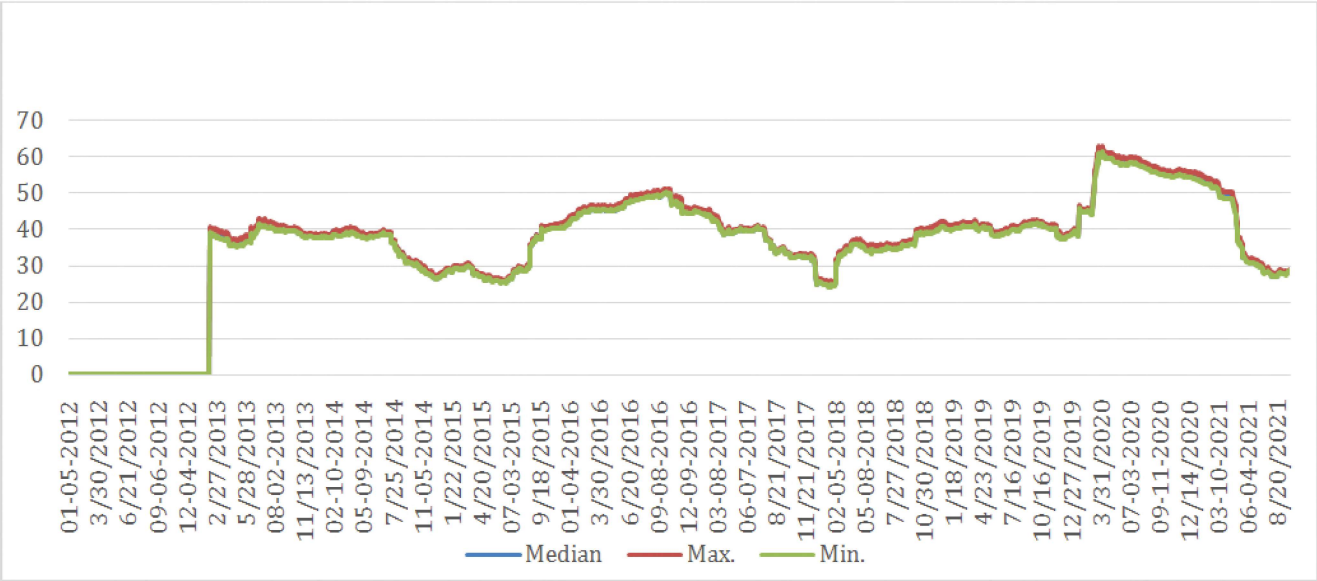
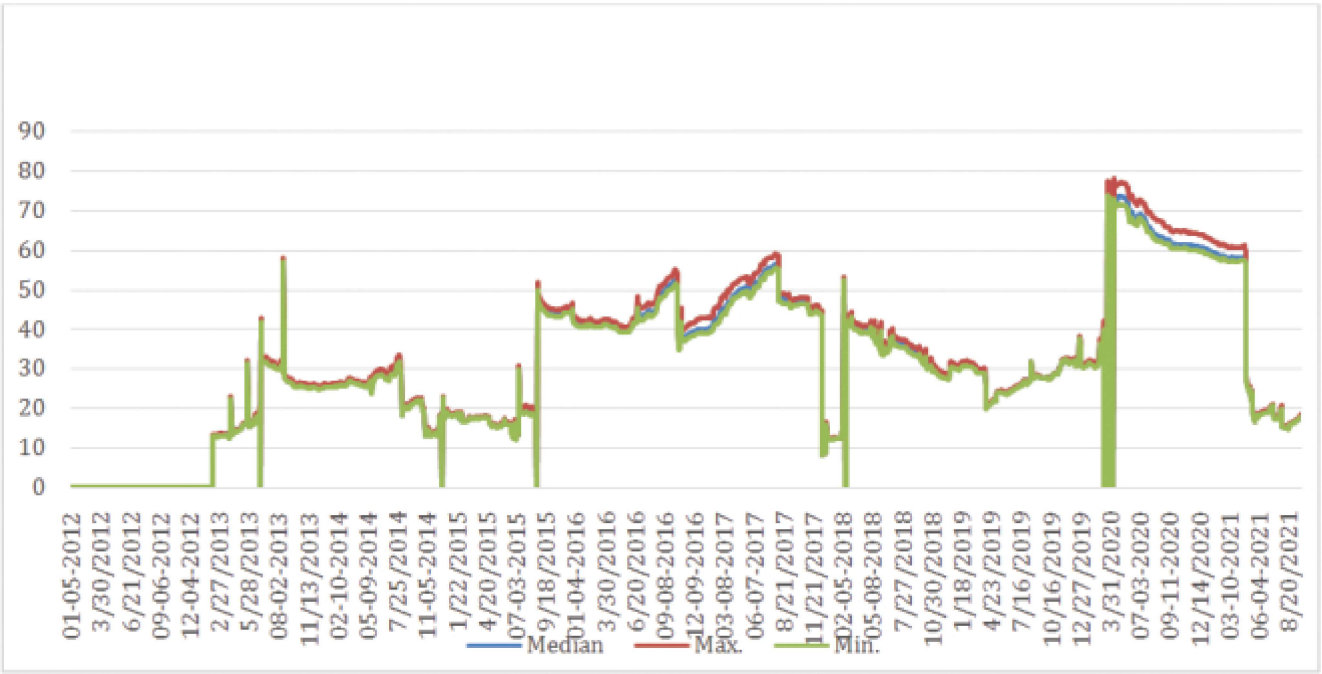


Figure 4: Volatility Spillovers in 9 Asian Stock Markets



5. CONCLUSION, IMPLICATIONS AND FUTURE SCOPE OF THE STUDY

Using the spillover index, we analyze how volatility shocks are propagated across nine Asian stock markets in this study. Geographically, politically, and militarily, the four countries are inextricably linked. In practice, examining the stock market's interconnectedness has become increasingly vital. Our study uses the Diebold & Yilmaz (2009a) spillover index method for exploring the pattern of return and volatility spillovers across 9 major Asian stock markets from 2012 to 2021. The empirical findings of our study clearly show that spillover of return and volatility behave similarly across the study period. Both the indices have shown a tendency to rise during the period of crisis and decline during the non-crisis period. It has also been observed that

the spike in volatility spillover index is higher than the return spillover index across markets during significant crises and is visible in plots of volatility spillovers. Even during the pandemic crises, the return and volatility spillovers followed a similar increasing pattern, but the percentage of volatility spillover index was higher when compared to the return spillover index. COVID-19 confirmed and cured instances had a stronger stock market reaction than COVID-19 death cases, which have a far weaker reaction, according to the estimation results. It's not surprising, given the impact of the COVID-19 problem on investor sentiment and global financial markets. During the research period from 2012 to 2021, Asian stock markets were increasingly interdependent as a result of growing market integration, as seen by higher return and volatility spillover during significant crisis times.

Investors, regulators, policymakers, authorities, and lawmakers all across the world can utilize our results as a tool. This analysis will better apprehend the inter dependencies of the four countries. Industry participants, such as portfolio managers and investors, can use volatility spillover data to estimate dynamic hedging ratios or ideal portfolio weights, which can help decrease contagion risk during a crisis. It is critical when portfolio managers and investors commit to risk diversification or hedge against specific stock indexes, especially in the face of global public emergencies like the present COVID-19 outbreak sweeping the globe. Regulators who want to keep the stock market from spreading contagion are in the same boat. To limit the danger of contagion from stock market interdependence, risk managers and regulators should base their decisions on ever-changing connections and directions of spillovers .

Finally, we propose that future studies incorporate other financial assets and markets in the four nations, such as derivatives, loans and receivables, bank deposits, commodity markets, currency markets and many more. Translating our results to other sectors and areas, such as medical coverage, power, energy, real estate, and various other industries will enable us to identify economy links and connections and determine how the COVID-19 pandemic affects other industries throughout the world.

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