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The Impact of Ukrainian Crisis on the Connectedness of Stock Index in Asian Economies

Ammar Jreisat [1*], Somar Al-Mohamad [2], Audil Rashid Khaki [2], Walid Bakry [3]

[1] *Department of Economics and Finance, College of Business Administration, University of Bahrain, Zallaq, Bahrain.*

[2] *College of Business Administration, American University of the Middle East, Eqaila 54200, Kuwait.*

[3] *School of Economics and Finance, Western Sydney University, Australia.*

Abstract

The main aim of this study is to measure the dynamic connectedness and spillover effects among emerging stock markets in Asia and the developed stock markets of the US and Europe in the ongoing Ukrainian crisis. The paper also aims to provide a comparative analysis of return and volatility spillovers during the global financial crisis in 2008, the COVID-19 pandemic, and the Ukrainian crisis. This paper utilizes the multiple structural beak test of Bai & Perron (2003) and also depicts the risk and return transmissions among these markets using the Diebold & Yilmaz (2012) method. The main outcomes of this study indicate that the stock markets in Asia are less affected by the political crisis in Ukraine as compared to the previous effects during the GFC and COVID-19 periods. The results also show that sensitivity of Asian financial markets to global shocks has been weakened in the wake of the Ukrainian crisis in favour of increased resilience of Asian stock indices to external shocks. These results carry an important implication for international and local investors as well as for policy makers in Asia, where investors have greater potentials for portfolio diversify and risk reduction across Asian markets.

Keywords:

Ukrainian Crisis; Spillover; Asian Stock Markets; Financial Connectedness; Diebold and Yilmaz (2012).

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1- Introduction

The financial connectedness among global and regional stock markets has become a significant determinant of economic growth as it facilitates the mobility of investment capital and enhances efficient fund allocation. Over the past 20 years, the financial markets' connectedness has become a burgeoning field of research in finance. The rippled interest in this field receives a continuing impetus from academic scholars, investors, and policymakers analogously with a greater emphasis on the periods of time characterized by a high degree of financial turbulence and political uncertainties. This line of research is recently substantiated by the notorious advancement of econometric toolkits and methodologies which have reshaped the comprehension of dynamic linkages among financial markets and provided more lucid picture of transmission channels of economic and financial shockwaves through the global financial system [1]. During crises, the degree of interdependence among stock markets comes back to the fore since they exhibit a relatively idiosyncratic behavior that defies the theoretical financial predictions and contests the unanimity of research evidences and outcomes in normal times. The outbreak of the coronavirus pandemic has wreaked havoc on the global financial system and led to a sharp decrease in macroeconomic and financial indicators throughout the world. In its wake, many economies were deprived of their main economic growth locomotives. The stock markets in Asian countries were not an exception; they experienced a significant loss in price indicators as well as a decreasing apatite of investors toward making further trade

* **CONTACT**: abarham@uob.edu.bh

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transactions and investment decisions. The risk and fear indicators have also increased sharply, and led to investment abandonments across the Asian region. Consequently, many researchers and decision makers have heated the debate on whether the COVID-19 crisis has brought the earth closer to a financial crisis more perilous than the global financial crisis in 2008.

Currently, the attention of researchers, scholars, and policymakers is shifting toward the impact of geo-political shocks on stock markets. The theme gained momentum with the outbreak of the war in Ukraine in February 2022. The effect of this conflict is expected to reverberate beyond its main epicenter in Eastern Europe to threaten financial stability and the macroeconomic outlook around the world. The direct engagement of Russia and Ukraine, who collectively account for a big proportion of the world's crude oil and commodity exports, is expected to exert inextricable pressure on the Asian countries, which account for more than 50% of the world's crude oil imports in 2021*. Additionally, the indirect involvement of many developed countries considered to be the main trading partners of Asia is also expected to affect the investment environment and balance of payments in Asian countries. Hence, the effect of the ongoing conflict in Ukraine on stock markets in Asia needs to come to the fore as it is anticipated to create a fertile atmosphere for uncertainty and volatility transmission among stock markets in developing and developed markets alike

The previous empirical works focused on the impact of the global financial crisis of 2008 and the COVID-19 pandemic on the stock market's performance in Asia, such as [1–8]. Nevertheless, limited number of empirical works attempting to study the impact of this ongoing conflict on stock markets performance to investigate the effect of the Ukrainian crisis on performance of large sample of stock markets [9, 10]. As no attention has been paid yet to the financial connectedness and dynamic spillover in the Asian region, this paper contributes to the existing literature by filling in this research gap, and it attempts to achieve the following: First, the paper measures the financial connectedness among stock markets in a group of Asian countries (Malaysia, Indonesia, Singapore, Thailand, Vietnam, and Hong Kong) with developed stock market indices during the ongoing Ukrainian crisis. Second, this study compares the impact of major financial, health, and political crises in the new millennium (GFC in 2008, COVID-19 in 2020, and the Ukrainian crisis) on return and volatility transmission among Asian and developed indices. Last, the study provides a comparative analysis of the role of domestic versus international events in initiating structural breaks, shocks, and abrupt changes in the stock markets of the Asian continent. We believe this is one of the earliest papers, if not the first, to identify the major structural breaks that occurred in Asian stock markets throughout the last fifteen years, and to compare the impact of the GFC, COVID-19 disease, and Ukrainian crisis on the dynamic connectedness and spillover effects among stock markets in selected Asian countries. For these aims, the paper employs the spillover and connectedness index of Dieblod & Yilmaz [11], as well as the impulse response analysis. The paper is organized as follows; section two presents the literature on financial connectedness among global and regional stock market indices, section three displays the data and method of study, section four presents the main outcomes of the study, and section five provides a conclusion and policy implication.

2- Literature Review

A significant strand of literature on financial connectedness among developed countries with other emerging countries has emerged in the last two decades. Empirical studies such as (Wang et al. [12], Simpson [13], Wong et al. [14], Hunter [15], Chaudhry & Boldin [16], Donadelli & Paradiso [17], Al-Mohamad et al. [18], and Bahloul & Ben Amor [19]) employed various correlation and cointegration techniques to measure financial integration among several financial assets and investments across the globe, such as the world's major stock indices. The empirical studies on financial connectedness of emerging stock markets in Asia became more attractive to research scholars due to the fast growing and rapid rise of Asian economies. For instance, Karim & Majid [20] examined the cointegration among the Asian stock markets of Malaysia, Indonesia, and Japan and the two major markets of the UK and US during the GFC. They utilized the Johansen-Jusilius cointegration test to analyze daily observations and concluded that the aforementioned markets exhibit a higher degree of financial connectedness. Assidenou [21] measured the interdependences among markets within three separate groups of stock indices; the (OECD) group, Pacific region group, and East Asia group where the results confirmed the cointegration between markets included in each group discretely. Seth and Sharma [22] measured the integration among Asian and US markets and found that stock indices in Asia are integrated with US markets in the long run. More recent bodies of literature have utilized the notable method of Dieblod & Yilmaz [11] to find the spillover index among stock markets. This method enables determining the direction of shock transmission among financial markets. For instance, Ahmad et al. [23], Kumar [24], Majumder & Nag [25], Trinh [26], Hung & Binh [1], Roni et al. [2], and Gulzar et al. [3] applied the Diebold & Yilmaz [11] method to find the transmission of return and volatility, as well as the direction of transmission, among different stock markets.

The spillover effects among Asian markets have come to the fore in recent years, and it became a controversial topic in the wake of the GFC as well as the COVID-19 pandemic. This was mainly due to the fact that investors seek a safe haven investment with low correlation with global markets during turbulence periods. Trinh [26] examined the

* https://www.worldstopexports.com/crude-oil-imports-by country/#:~:text=Year%20over%20year%2C%20total%20spending,India%2C%20South%20Korea%20and%20Japan.

regional as well as international transmission effects of the return and volatility among the equity markets of Vietnam and its Asian counterparts using the MGARCH method and concluded that there is a low level of financial integration of stock market in Vietnam into the regional markets. On the other hand, Hung & Binh [1] found that the volatility of the Chinese stock market had a significant impact on its Vietnamese counterpart during the crisis. They estimated the daily returns and volatility spillover effects in common stock prices between China and Vietnam pre and post GFC via the GARCH-BEKK model. Furthermore, Roni et al. [2] examined the degree of contagion and interdependence across the stock markets of six Asian emerging countries using the GARCH model. The outcomes suggested that the degree of linkage among these markets had declined sharply prior to the GFC era. Additionally, Gulzar et al. [3] investigated the spillovers among stock market indices in Hong Kong, China, Taiwan, Korea, and Singapore, and assessed the dynamic volatility transmission among these markets by employing the GARCH methodology. The results showed that strong volatility associations among the Chinese and the four emerging stock markets in GFC time. Habiba et al. [4] measured the cointegration and volatility spillovers dynamics between stock markets in the USA and South Asia, namely, India, Pakistan, and Sri Lanka, using the EGARCH model. The outcomes suggested that the stock market in the USA exhibits a causal relationship with emerging markets in the short term. The results also revealed that asymmetric volatility spillover effects are significant for all selected stock markets in pre-, during-, and post-GFC crisis sub-periods.

Regarding the impact of COVID-19 on the financial connectedness of Asian stock markets, several studies investigated the dynamic connectedness among these markets during the pandemic period. For instance, Sharma [5] studied whether the COVID-19 pandemic has modified the dynamics in volatility within the Asian region and concluded that during the pandemic there was a significant relationship between Asian regional level stock market volatility and country-level stock market volatility. Likewise, Choi et al. [6] investigated the dynamic correlations between stock markets in China, South Korea, Japan, and the United States (US) in the wake of the GFC and COVID-19. The outcomes revealed an increased interdependence among Asian and developed stock indices during the two crisis periods, while the size of volatility broadcast to other countries was time-varying. Samitas et al. [27] examined the impact of the COVID-19 pandemic on major stock markets in the world, including the developed and emerging indices. They found that prompt connection is caused by multiple sanitary measures, such as lockdown.

Moslehpour et al. [28] utilized multiple DCC-GARCH modulations to quantify the risk spillover among a sample of global stock markets during the pandemic period. The finding of the paper suggested that risk transmission among global markets has increased drastically in the wake of the pandemic and was mainly initiated by developed stock indices in the US and Europe. Lia et al. [29] measured the degree of uncertainty in stock markets associated with COVID-19. The results suggest that COVID-19 fear is the main cause of stock market volatility. The outcomes also indicate that stock market performance and economic growth levels have decreased significantly in tandem with the death and infection cases. Kamaludin et al. [7] measured the co-movement of stock markets in Malaysia, Indonesia, Singapore, Thailand, and the Philippines with the Dow Jones stock index in pre and during the pandemic. The study found that at the beginning of the pandemic outbreak, the stock markets of Singapore, Malaysia, and Indonesia reacted significantly to the announced number of infection cases, whereas the markets in the Philippines and Thailand exhibited coherency during the pandemic. The study also found that returns in all equity indices under consideration exhibited noticeable coherence with the Dow Jones returns. Anh & Gan [30] assessed the effect of lockdown due to the pandemic on stock market performance in Vietnam. The results contended that the lockdown period had a positive impact on stock returns in the Vietnamese market. Moreover, Aziz et al. [8] investigate the dynamic connectedness among developed and ASIAN+3[*] stock markets between 2005 and 2021. The study concludes that COVID-19 exhibited the most severe impact on return and volatility spillovers among these markets, as compared to the GFC and the European debt crisis.

In the wake of the ongoing Ukrainian crisis, the attention of researchers starts shifting toward the impact of geo-political shocks on stock markets. Few attempts have been noticed so far to investigate the effect of this crisis on stock market performance. For instance, Federle et al. [9] studied the returns on equity for 66 countries during the first weeks of the Russian invasion of Ukraine in February 2022. They found evidence of "proximity penalty" for the equity returns: proximity to Ukraine is associated with a stronger decline in the equity market for countries. Boungou & Yatie [10] measured the effect of the Ukraine–Russia war and world stock market returns, including 94 indices, for the time window from January to March 2022. The study found a negative impact of the crisis on stock market performance. It can be clearly noticed from the literature above that there is no empirical research yet to highlight the direct effect of the ongoing political crisis on the financial contagion and direct spillovers among stock markets in Asia, and between Asian and developed markets. Therefore, this study adds to the existing literature as the first empirical study (to the best of our knowledge) on the volatility spillover alongside the financial connectedness among the emerging stock markets in Asia during the main events and shocks in the last two decades, starting with the global financial crisis of 2008, including COVID-19 pandemic intensification in 2020, and ending with the current Ukrainian crisis.

[*] ASIAN+3 represents the stock markets in Singapore, Indonesia, Korea, Japan, the Philippines, Malaysia, China, Vietnam, and Thailand.

3- Data and Method of Study

The empirical analysis in this paper is based on daily stock prices for a sample of six stock markets in Asia and two proxies for developed stock indices. The sample of Asian markets including Malaysia, Indonesia, Singapore, Thailand, Vietnam, and Hong Kong. The Euronext100 and S&P500 selected to proxy for advanced markets in Europe and US, respectively. The research in this study applies the Bai & Perron [32] test for multiple structural breaks. For this test, we consider a data range from July 2008 to July 2022 in order to depict whether the three crises (GFC, COVID-19, and Ukrainian war) have caused a break in time series variables. Also, we utilize the connectedness measure of Diebold and Yilmaz [11] for the three sub-periods separately, in addition to the Impulse Response Analysis which allows for detailed investigation of time path and magnitude of response of Asian markets to shocks in developed markets. The analysis in this paper covers three different sub-period of Global financial crisis in 2008 (second half of 2008), COVID-19 pandemic (second half of 2020), and the Ukrainian crisis (first half of 2022). The data utilized in this analysis are MSCI indices obtained from the Datastream. The daily observations have significant advantage over other data frequencies a it allows for proper depiction of short-lived change in connectedness among financial market than with monthly or weekly observations.

3-1- Testing for Multiple Structural Breaks: Bai & Perron (2003) [32]

The multiple structural breaks approach proposed by Bai & Perron [32] is considered as more preferable than its peers as it enables for determining both of number and time location of breaks alongside with their corresponding autoregressive coefficients. Moreover, this method permits an instantaneous forecast of breaks and reforecast of break points of time (Enders and Sandler, [31]. Another advantage of Bai & Perron [32] method is allowing for heteroskedasticity and autocorrelation in error, and this in turn investigates if the realization of one additional break can lead to reduce the sum of forecasting residual squares (Antoshin et al, [33]). The null hypothesis of no structural breaks in time series variables is tested against the alternative hypothesis of multiple structural breaks (up to five break points). According to Bai & Perron [32], the multiple linear regression model with r breaks; $(r+1)$ regimes are presented as follow:

$$G_t = x_t'\beta + z_t'\delta_j + u_t \; (t = T_{j-1}+1, \ldots, T_j) \tag{1}$$

where $j = 1, \ldots, r+1$, $T_0 = 0$ and $T_{r+1} = T$. G_t denotes the dependent variable at time *t*. $x_t(p \times 1)$ and $z_t(q \times 1)$ represent the vectors of covariance. β and δ_j $(j = 1, \ldots, r+1)$ are the corresponding vectors of coefficients. $(T_1, \ldots, T_m)$ show unknown breaks, and u_t denotes disturbance at time *t*. This equation demonstrates partial structural change as vector β is not subject to changes. When $p + 0$, we can obtain a pure structural break model where coefficients are subject to modification, and the variance u_t not constant. The multiple linear regression written above can be demonstrated in a matrix form as:

$$G = X\beta + \bar{Z}\delta_j + U \tag{2}$$

where $G = (G_1, \ldots, G_T)'$, $X = (x_1, \ldots, x)'$, $U = (u, \ldots, u_T)'$, and $\delta = (\delta_1', \delta_2', \ldots, \delta_{m+1}')'$. Z at $(T_1, \ldots, T_m)$, is the matrix which diagonally partition. The values $\delta^0 = (\delta_1^{0\prime}, \delta_2^{0\prime}, \ldots, \delta_{m+1}^{0\prime})'$ and $(T_1, \ldots, T_m)$ are utilized to show the true values of δ and the exact break points. For each *r*-partition $(T_1, \ldots, T_r)$, the least square estimates of parameters β and δ_j are calculated through the minimized sum of square residuals. Bai & Perron [33] model propose three different test statistics to depict multiple structure changes in the linear model representation. The statistics are:

3-1-1- Structural Stability versus Fixed Number of Breaks

This test is sup F type which test the null hypothesis of no structural break versus the alternative hypothesis of existence of fixed number of breaks n. The test statistic is presented as follow:

$$X_T(\lambda_1, \ldots, \lambda_n; q) = \frac{1}{T}\left(\frac{T-(n+1)q}{nq}\right)\hat{\delta}'R'\left(R\hat{V}\left(\hat{\delta}\right)R'\right)^{-1}R\hat{\delta} \tag{3}$$

where R denots matrix $(R\delta)' = (\delta_1' - \delta_2', \ldots, \delta_n' - \delta_{n+1}')$, while $\hat{V}\left(\hat{\delta}\right)$ estimates of variance covariance matrix of $\hat{\delta}$ which is robust to serial correlation. The sup X type test statistic is defined as:

$$\sup X_T(n; q) = \sup_{(\lambda_1, \ldots, \lambda_n) \in \Lambda_\epsilon} X_T(\lambda_1, \ldots, \lambda_n;\, q) = X_T\left(\hat{\lambda}_1, \ldots, \hat{\lambda}_n;\, q\right) \tag{4}$$

The breaks estimate presented by $\left(\hat{\lambda}_1, \ldots, \hat{\lambda}_n\right)$ reduces the sum of squared residuals under specified trimming region. This is equivalent to F-test as the estimated breaks are steady even in the existence of serial correlation.

3-1-2- Double Maximum Test

The second test statistic proposed by Bai & Perron [32] is for structural stability against unknown number of breaks. The main purpose of this measure is to enable for the depiction of structural break points without pre-determination of a fixed number of breaks. It includes two statistics for testing null hypothesis of no structural breaks against the alternative hypothesis of an unknown number of breaks. The first test statistic, denoted as *UDmax*, is an equally weighted version, while the second test, denoted as *WDmax*, applies weights to individual test such that the marginal *p*-values are equal across values of r.

3-1-3- Sequential Test

The last test statistic is the sequential test of ℓ versus $(\ell + 1)$ breaks. The $(\ell + 1)$ tests of the null hypothesis of ℓ break against the alternative of $\ell + 1$ number of breaks. The null hypothesis of ℓ number of breaks is rejected in favor of the alternative hypothesis of $(\ell + 1)$ break points when the highest value of the sup $F_T(1; q)$ is sufficiently large, and the break dates are selected correspondingly as points in time associated with the overall maximum. The empirical investigation of multiple structural breaks in this paper is based on double maximum and sequential tests, for which we employ the sequential test of $(\ell + 1|\ell)$ only for time series that exhibit significant UD_{max} values as this technique generates best outcomes [33].

3-2-Testing for Return and Volatility Spillovers: Diebold & Yilmaz (2012) [11]

The financial connectedness among Asian and developed stock markets is measured by Diebold Yilmaz [11] spillover methodology. Initially, we apply the Dynamic Conditional Correlation (DCC) of the GARCH method introduced by Engle [35] to depict the conditional heteroskedastic comportment of time series variables. Then, we calculate the spillover index introduced by Diebold and Yilmaz [11] using the generalized version of the VAR model as well as the variance decomposition matrix. Assume the covariance stationary VAR*(p)* as:

$$L_t = \sum_{i=1}^{p} \Psi_i l_{t-1} + \varepsilon_t \tag{5}$$

where $l_t$is n×1 vector of the endogenous variables, Ψ_i represents the n×n autoregressive coefficient matrices, the ε_t depicts vector of the serially uncorrelated error components. The moving average representation can be written as $l_t = \sum_{j=0}^{\infty} \mathrm{A}_j \varepsilon_t$, A_j which contents the recursion of $\mathrm{A}_j = \Psi_1 \mathrm{A}_{j-1} + \Psi_2 \mathrm{A}_{j-2} + \cdots . + \Psi_p \mathrm{A}_{j-p}$ where A_0 is the identity matrix of n×n, and A_j for $j < 0$. The H-step ahead generalized forecast error variance decomposition is presented as:

$$\theta_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma_{e_j})^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)} \tag{6}$$

The connectedness and spillover index encompass $n \times n$ matrix c $\theta(H) = [(\theta_{ij}(H)]_{i,j=1,2,}$ where coefficients display the contribution of the variable, say j to the forecast error of i variable. The entries of variance decomposition matrix are normalized by their corresponding row sum as own and cross variable contribution do not sum to one under the assumption of generalized decomposition. The net pairwise directional connectedness is presented as:

$$C_{ij} = C_{i \leftarrow j}(H) - C_{i \leftarrow j}(H) \tag{7}$$

This index includes two forms for directional effect measure; 'from' and 'to' for which the total directional index from all variables to i is presented by $C_{i \leftarrow .}(H)$, which can be calculated by:

$$C_{i \leftarrow .}(H) = \frac{\sum_{j=1, j \neq i}^{N} \widetilde{\theta_{\iota J}}(H)}{\sum_{i,j=1}^{N} \widetilde{\theta_{\iota J}}(H)} \times 100 = \frac{\sum_{j=1, j \neq i}^{N} \widetilde{\theta_{\iota J}}(H)}{N} \times 100 \tag{8}$$

Similarly, the contribution of variable i to a shock its counterparts is based on the partial aggregation. Consequently, the total directional connectedness from this market to all other markets is denoted by $C_{. \leftarrow i}(H)$ and calculated as:

$$C_{. \leftarrow i}(H) = \frac{\sum_{j=1, j \neq i}^{N} \widetilde{\theta_{J\iota}}(H)}{\sum_{i,j=1}^{N} \widetilde{\theta_{\iota J}}(H)} \times 100 = \frac{\sum_{j=1, j \neq i}^{N} \widetilde{\theta_{J\iota}}(H)}{N} \times 100 \tag{9}$$

The net total connectedness is presented as:

$$C_i(H) = C_{. \leftarrow i}(H) - C_{i \leftarrow .}(H) \tag{10}$$

Finally, the total combination of variance decomposition across all variables will indicate for the total connectedness index which can be computed as:

$$C(H) = \frac{\sum_{i,j=1, i \neq j}^{N} \widetilde{\theta_{\iota J}}(H)}{\sum_{i,j=1}^{N} \widetilde{\theta_{\iota J}}(H)} \times 100 = \frac{\sum_{i,j=1, i \neq j}^{N} \widetilde{\theta_{\iota J}}(H)}{N} \times 100 \tag{11}$$

3-3- The Impulse Response Function

The empirical analysis in this paper employs the generalized impulse response analysis proposed by Pesaran & Shin [36] to capture the dynamic patterns of Asian stock markets' reaction to shock in developed indices. The impulse response analysis is performed through Vector Autoregressive (VAR) model as follows:

$$\mathrm{F}_t = b_{10} - b_{12}\mathrm{w}_t + \gamma_{11}\mathrm{f}_{t-1} + \gamma_{12}\mathrm{w}_{t-1} + \varepsilon_{\mathrm{f}t} \tag{12}$$

$$\mathrm{W}_t = b_{20} - b_{21}\mathrm{f}_t + \gamma_{21}\mathrm{f}_{t-1} + \gamma_{22}\mathrm{w}_{t-1} + \varepsilon_{zt} \tag{13}$$

F and W represent stock market indices, where b_{10} and b_{20} are intercept terms. f_t and w_t can influence each other through $-b_{12}$ and $-b_{21}$ that represent simultaneous effect of unit change of w_t on f_t, and γ_{12} and unit change in w_{t-1} on f_t, respectively. The ε_{yt} and ε_{zt} denote white-noise disturbances reflecting the innovations or shocks in f_t and w_t respectively.

The moving average representation form of the VAR model in its matrix form is:

$$\begin{bmatrix} f_t \\ w_t \end{bmatrix} = \begin{bmatrix} \bar{f} \\ \bar{w} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix} \tag{14}$$

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i} \tag{15}$$

The moving average representation enables for the examination of interaction between orders and sequences of time series variables. The coefficient ϕ_i denotes the effect of shocks in ε_{yt} and ε_{zt} on the time path of variables f_t and w_t. The four functions $\phi_{11}(i)$, $\phi_{12}(i)$, $\phi_{21}(i)$ and $\phi_{22}(i)$ represent the impulse response functions to depict the behavior of variable in the system in response to various shocks in other variables.

4- Results and Discussion

The first aim of this paper is to highlight the major structural breaks occurred in Asian stock markets throughout the last fifteen years to depict the impact of the different financial, geopolitical and health crises on these markets. Table 1 illustrates the outcomes of Bai & Perron [32] test for multiple structural changes in Asian stock markets over the time window from beginning of 2008 to end of June 2022. The results of UD_{max} tests are significant for all variables and this indicates that at least one structural break exists in the time series we apply the sequential test $(\ell + 1|\ell)$ for Asian stock indices to explore the number of structural changes. The $(\ell + 1|\ell)$ test statistics indicate that stock markets in Singapore, Thailand, and Vietnam, were subject to four main structural breaks between 2008 and mid of 2022, whereas their counterparts in Hong Kong has experienced three breaks, and two breaks were depicted for Malaysia and Indonesia. The outcomes demonstrate that GFC caused a significant break in stock markets of Thailand, Vietnam, and Hong Kong, whereas the COVID-19 outbreak has caused a significant break in all variables during 2020, except for Hong Kong market where the break occurred in the second half of 2019 which can also be imputed to the pandemic. It can be also noticed that in at the beginning of 2017, the stock indices of Singapore and Thailand were subject to significant structural breaks. This could be explained by the US-China trade war that was intensified in 2016 that affected the FDI and trade among China and its main trading partners including Singapore and Thailand. Results in Table 1 also reveal that stock market of Thailand is explicitly affected by the ongoing Ukrainian crisis accompanied with the current political tension among US and China since both countries lie on the top of trading partner list of Thailand.

Table 1. Bai & Perron (2003) Test for Multiple Structural Breaks [32]

Variable	UD_{max}	WD_{max}	$F_T(2\|1)$	$F_T(3\|2)$	$F_T(4\|3)$	$F_T(5\|4)$	*Optimal Number of Breaks*	*Break Dates*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Malaysia	20.63***	32.94***	11.78**	4.37	-	-	2	08/2010, 02/2020
Indonesia	15.13***	16.90***	9.50*	5.13	-	-	2	03/2017, 02/2020
Singapore	13.39***	16.86***	20.27***	12.87**	8.88*	3.15	4	03/2010, 02/2017, 03/2020, 04/2022
Thailand	24.92***	43.58***	14.27***	12.92**	39.13***	2.04	4	08/2008, 10/2012, 06/2015, 08/2020
Vietnam	13.60***	18.38***	11.39**	13.60**	10.21*	7.78	4	03/2008, 05/2011, 01/2017, 04/2020
Hong Kong	32.13***	57.37***	14.44***	20.65***	4.75	-	3	02/2008, 11/2012, 08/2019

Notes: The UD_{max} critical values equal 12.37, 8.88 and 7.46 at 1, 5 and 10% significance levels, respectively. The WD_{max} critical values equal 13.83, 9.91 and 8.20 at 1, 5 and 10% significance levels, respectively. For critical values of $F_t(2|1)$, ℓ=1,….., $F_t(5|4)$ please refer to Bai and Perron (2003) [32].

The main goal of this paper is to measure the financial connectedness among Asian stock markets and between Asian and developed markets (proxied by the EuroNext100 and S&P500 indices) during three major events in the last two decades: the global financial crisis, the COVID-19 pandemic, and the Ukrainian crisis. For this purpose, the research in this paper employs Diebold and Yilmaz [11] spillover indices for return and volatility during the three sub-periods. Table 2 illustrates the outcomes of return spillovers among these indices and is composed of panels A, B, and C for return spillover indices during the GFC, COVID-19, and Ukrainian crisis, respectively. Panel A in Table 2 demonstrates that the total return spillover during the GFC amounted to 61.4%, which is higher than the return spillover indices reported for COVID-19 and the Ukrainian crisis sub-periods. The analysis of the directional return spillover reveals that in GFC time, a larger proportion of forecast error variance comes from other markets as compared to the market's own error variation. The proportions of forecast error variance of Asian markets caused by other markets in the system has decreased sharply in COVID-19 and Ukrainian crisis. Table 2 also illustrates that the main transmitters of return shocks during the three subperiods are Singapore and Hong Kong; their contributions to their Asian counterparts equal 75.2% and 64% from Singapore in GFC, 45% and 29.5% during COVID-19, and 34.9% and 49.2% in the Ukrainian crisis, respectively. On the other hand, the most endogenous (affected by other) markets were Thailand and Singapore, as they had high percentages of their forecast error variances generated by shocks in other market returns. The variation and changes in return on developed stock market indices represented by European and US indices seem to be highest in the GFC as compared to the pandemic and the Ukrainian conflict eras, and this could be explained by the absence of geographic proximity among Asian countries and the epicenter of the Ukrainian war; however, the repercussions of such a large political event are ultimately expected to spread through direct and indirect channels to shock the majority of financial markets around the world.

Table 2. Diebold and Yilmaz Test Results for Return Spillovers during the Three Sub-periods

Panel A: Return Spillovers During Global Financial Crisis (Total spillover = 61.4%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	60.8	2.4	4.3	5.6	5.8	1.1	16.0	4.0	39.2
HONGK	17.8	44.4	4.6	2.8	10.4	3.2	14.8	2.1	55.6
INDONESIA	14.4	11.4	42.5	1.5	11.8	5.7	11.4	1.2	57.5
MALAYSIA	14.1	8.2	10.1	41.8	9.3	4.1	6.3	6.2	58.2
SINGAPORE	21.7	22.1	8.6	5.9	19.5	4.2	13.4	4.6	80.5
THAILAND	20.4	21.1	6.2	3.4	10.7	27.9	8.8	1.3	72.1
US	44.6	5.7	4.3	3.7	4.3	9.1	22.5	5.8	77.5
VIETNAM	15.2	4.3	12.7	1.6	11.7	1.7	3.6	49.3	50.7
Contribution to others	148.2	75.2	50.9	24.5	64.0	29.0	74.3	25.2	491.3
Panel B: Return Spillovers During COVID-19 Pandemic (Total spillover = 42.7%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	80.1	3.4	4.1	2.4	0.3	2.1	4.6	3.0	19.9
HONGK	24.3	53.6	1.4	2.1	2.3	4.8	5.6	5.8	46.4
INDONESIA	14.1	8.7	59.5	3.1	4.6	2.5	3.3	4.2	40.5
MALAYSIA	4.0	2.9	4.8	70.5	4.7	1.8	6.5	4.7	29.5
SINGAPORE	30.4	12.6	4.6	1.3	35.7	5.1	6.8	3.4	64.3
THAILAND	22.3	4.5	5.2	2.6	10.7	47.8	5.0	1.9	52.2
US	29.7	3.0	5.0	2.5	2.7	4.0	50.0	3.1	50.0
VIETNAM	6.5	9.8	2.0	4.8	4.2	2.3	9.4	60.9	39.1
Contribution to others	131.3	45.0	27.1	18.8	29.5	22.7	41.2	26.2	341.8
Panel C: Return Spillovers During Ukrainian Crisis (Total spillover = 34.9%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	68.5	4.2	4.6	2.1	5.7	5.8	8.6	0.5	31.5
HONGK	16.2	56.1	1.9	3.0	15.4	2.9	1.5	3.0	43.9
INDONESIA	4.3	3.4	80.7	3.3	2.0	2.8	1.0	2.4	19.3
MALAYSIA	4.2	2.8	6.1	75.6	3.3	1.0	4.2	2.9	24.4
SINGAPORE	32.5	7.5	2.6	0.8	44.0	6.4	3.9	2.4	56.0
THAILAND	14.1	10.6	5.2	5.3	11.2	49.5	4.0	0.2	50.5
US	15.0	3.9	2.5	1.2	9.0	3.6	63.7	1.1	36.3
VIETNAM	2.6	2.5	1.4	1.4	2.6	4.5	2.4	82.7	17.3
Contribution to others	88.8	34.9	24.3	17.0	49.2	27.0	25.6	12.4	279.2

Table 3 demonstrates the results of the volatility spillovers and transmissions among the Asian stock indices and developed markets during the three crises. Initially, the contribution from stock market indices in the system has generally increased risk transmission as compared to return spillovers (Table 2). Table 3 illustrates that the main, and maybe most significant, result of volatility spillover in this paper is that the gross volatility spillover index is noticeably higher in the GFC (67.3%) as compared to COVID-19 (57%) and the Ukrainian crisis (54.2%). It is important to highlight the main difference between net transmitter and receiver markets, where the former states that the contribution of one market to others in the system is greater than the contribution of other variables to movements in this market, whereas under the latter (net receivers), the contribution from other variables in the system to one market is larger than its own effect on others. Following this role, we can notice that the stock markets of Thailand, Hong Kong, and Singapore are the main net volatility transmitters in the GFC, COVID-19, and Ukrainian crisis sub-periods, respectively. On the other hand, most Asian markets seem to be net receivers of shocks transmission during the pandemic and the political conflict times. The outcomes in Table 3 also display that stock markets in Europe were more influential on their Asian counterparts during the pandemic, whereas the effect of US market fluctuations was higher and more obvious during the GFC. The main implications of the outcomes in Table 3 are that the oscillations and instabilities in the emerging stock markets in Asia are less affected (less endogenous) by fluctuations in developed markets compared to political and health crises.

Table 3. Diebold and Yilmaz Test Results for Volatility Spillovers during the Three Sub-periods

Panel A: Volatility Spillovers During Global Financial Crisis (Total spillover = 67.3%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	36.7	1.2	2.3	4.2	5.7	13.7	28.6	7.6	63.3
HONGK	9.7	26.5	1.0	1.8	7.2	28.7	18.8	6.3	73.5
INDONESIA	2.9	22.0	23.3	0.6	10.2	12.4	23.2	5.4	76.7
MALAYSIA	6.0	27.3	5.8	23.3	6.3	18.1	12.0	1.1	76.7
SINGAPORE	3.5	16.4	2.0	3.8	26.0	21.0	22.5	4.8	74.0
THAILAND	12.8	10.1	3.9	2.8	8.6	28.0	28.0	5.8	72.0
US	16.4	3.7	1.9	4.5	8.1	12.7	42.0	10.7	58.0
VIETNAM	4.3	1.8	2.4	3.0	23.2	0.2	9.5	55.7	44.3
Contribution to others	55.6	82.5	19.2	20.6	69.4	106.9	142.6	41.8	538.6
Panel B: Volatility Spillovers During COVID-19 Pandemic (Total spillover = 57%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	72.1	8.7	6.5	4.6	0.7	0.6	2.9	4.0	27.9
HONGK	52.2	34.5	7.2	0.8	1.0	1.4	1.4	1.5	65.5
INDONESIA	34.5	7.4	40.2	13.5	0.5	1.2	0.5	2.1	59.8
MALAYSIA	3.7	3.5	2.7	73.8	1.5	6.7	6.2	2.0	26.2
SINGAPORE	59.3	6.1	3.4	3.4	17.6	2.1	2.0	6.1	82.4
THAILAND	44.3	2.4	16.3	0.9	2.4	25.9	7.3	0.5	74.1
US	45.7	4.1	1.8	19.5	0.9	1.2	25.8	1.0	74.2
VIETNAM	21.2	12.2	0.3	1.5	1.1	0.6	9.0	54.2	45.8
Contribution to others	260.7	44.3	38.3	44.1	8.1	13.9	29.3	17.2	456.0
Panel C: Volatility Spillovers During Ukrainian Crisis (Total spillover = 54.2%)									
	EUNX100	**HONGK**	**INDONESIA**	**MALAYSIA**	**SINGAPORE**	**THAILAND**	**US**	**VIETNAM**	**From Others**
EUNX100	45.6	6.5	4.1	7.9	12.9	15.4	6.2	1.4	54.4
HONGK	19.9	20.8	5.6	9.2	33.5	2.5	0.3	8.2	79.2
INDONESIA	18.0	0.6	56.7	3.4	10.3	2.0	7.8	1.2	43.3
MALAYSIA	7.5	5.4	1.4	37.6	40.3	3.5	0.9	3.4	62.4
SINGAPORE	23.9	1.3	0.5	3.6	58.9	2.3	3.7	5.7	41.1
THAILAND	9.9	2.9	3.1	2.8	51.5	26.7	1.5	1.6	73.3
US	13.0	16.3	0.6	0.2	23.7	2.3	43.1	0.9	56.9
VIETNAM	3.7	0.6	2.7	0.8	1.5	12.9	1.2	76.6	23.4
Contribution to others	95.9	33.7	18.0	27.8	173.8	40.8	21.6	22.4	434.0

Overall, the results of Dieblod & Yilmaz [11] spillover index denote that, in general, the total return spillover effect among Asian and developed indices is higher in GFC (61.4%) compared to COVID-19 and the Ukrainian war sub-periods (42.7% and 34.9%, respectively). Analogously, the magnitude of volatility transmission among these markets exhibits a higher score in the GFC (67.3%) as compared to the pandemic and war times (57 % and 54.2%, respectively). These outcomes indicate that the expected return on investment in Asian financial markets are more sensitive and influenced by transmission from developed markets during the GFC than in COVID-19 and Ukrainian conflict periods, the results also contend that the risk transmission from developed to Asian stock markets has decreased over time, and this indicates for higher resilience of stock indices in Asian countries to shock wave transmission during uncertainty and turbulence periods. The findings in this study seem to contradict in part the outcomes of Samitas et al. [27], and Moslehpour et al. [28], who contended that international financial markets are becoming more connected over time. However, the results in this paper indicate potential for portfolio diversification among Asian and developed markets [37].

The generalized impulse response analysis of Asian stock markets to shocks in European, and US markets is also performed in this study. Figure 1 illustrates the response of Asian indices to the shock in standard deviations in developed markets during the GFC for a ten-week horizon. It can be noticed that Asian markets exhibit an immediate response to shock in other markets. Also, an impulse in EU and US markets seems to have initiated a positive response in all Asian indices. Figure 2 illustrates the impulse response function during the COVID-19 pandemic. It can be noticed that the stock markets in Singapore and Thailand exhibit a negative response to a one standard deviation shock in the US market. Lastly, Figure 3 represents the outcomes of the impulse response analysis during the Ukrainian crisis. The results in Figure 3 demonstrate that Asian stock indices respond to shocks in other markets positively, except for Vietnam, which exhibits a negative response to an impulse in the European composite index. The results of the impulse response function indicate, in general, that the stock markets in Asia are not isolated from changes and impulses in international equity markets and that they tend to respond immediately to external shocks regardless of the long-run trajectory of the response. The results seem to have different implications for local and international investors than the outcomes of return and volatility spillover indices. That while the former (Diebold & Yilmaz [11]) test results show a decrease in Asian stock markets' connectedness with global markets over time, the latter (impulse response results) seem to provide less hope to international investors for the potential portfolio diversification opportunities since Asian markets are connected, rather than isolated, from shocks and movements in global financial markets.

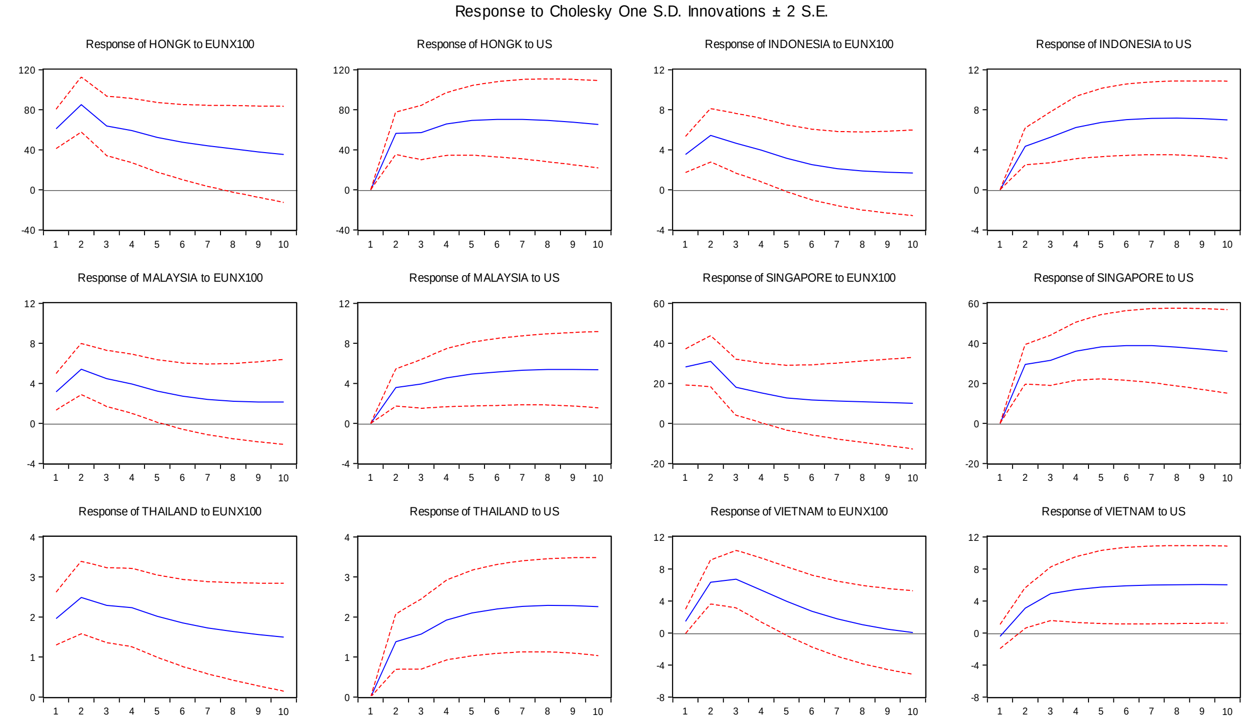

Figure 1. **Response of Asian Stock Market to an Impulse in European and US Stock Markets During GFC**

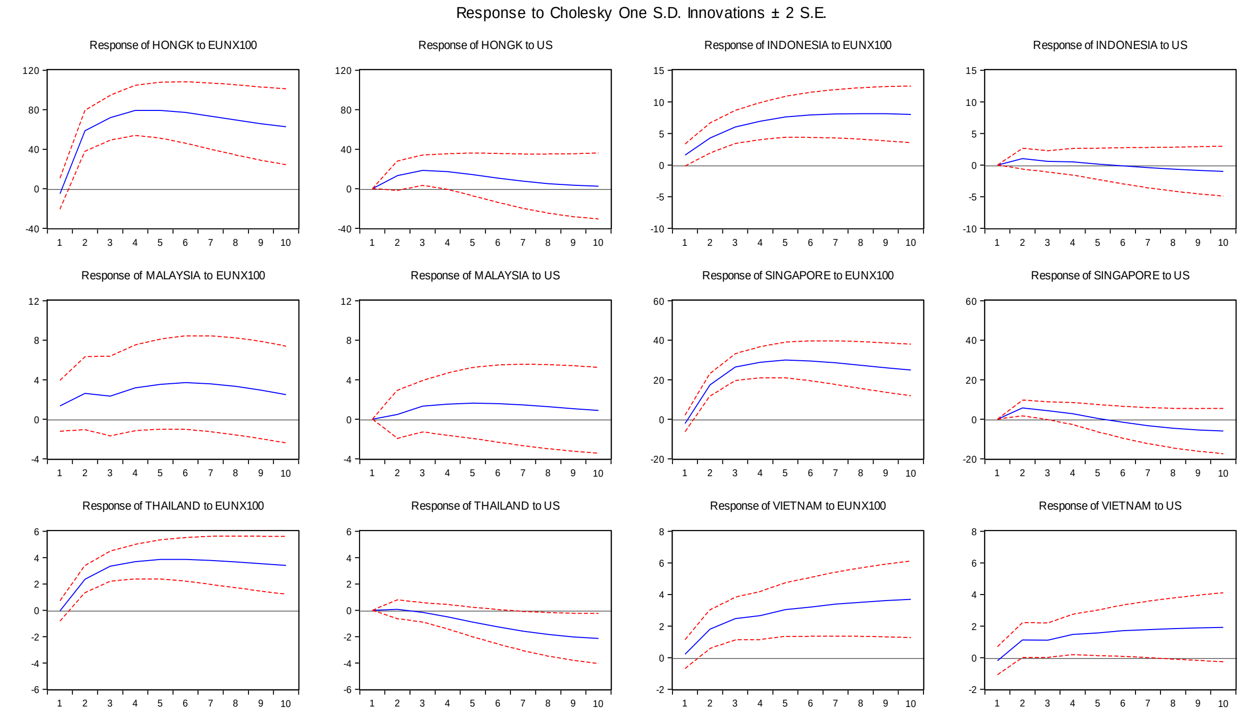

Figure 2. **Response of Asian Stock Market to an Impulse in European and US Stock Markets During COVID-19 Pandemic**

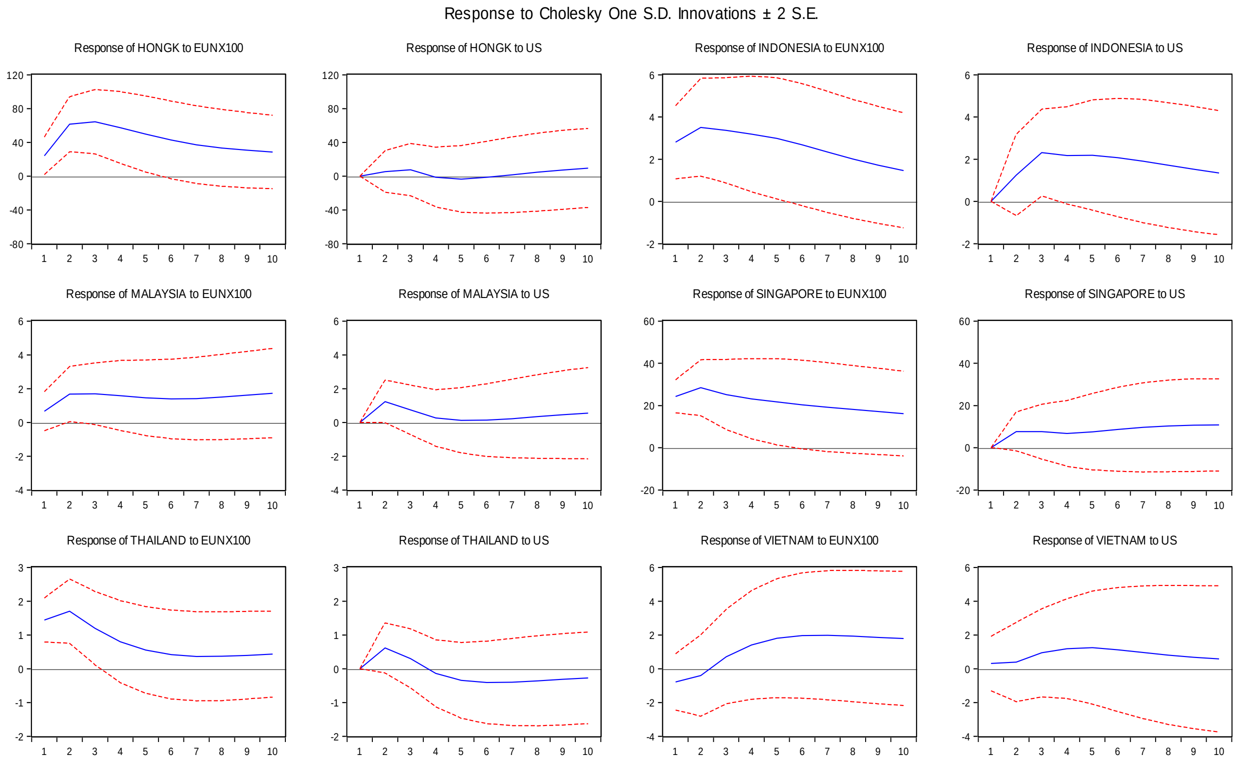

Figure 3. Response of Asian Stock Market to an Impulse in European and US Stock Markets During Ukrainian Crisis

5- Conclusion and Policy Implication

This paper aims at assessing the financial connectedness and spillover effects among stock markets in Asia and developed countries during the ongoing Ukrainian crisis. The paper also compares the impact of the GFC, COVID-19, and the Ukrainian crisis on risk and return transmission among these indices. The empirical analysis encompasses the use of the Bai-Perron test for multiple structural breaks in addition to Diebold & Yilmaz [11] spillover index as well as the generalized impulse response analysis in the three sub-periods. The outcomes of the structural break test reveal that stock markets in Singapore, Thailand, and Vietnam were subject to multiple structural changes between 2008 and mid-2022. The GFC is found to be the main source of structural change in Asian markets, whereas the stock market in Thailand is the only market affected by the ongoing Ukrainian crisis. The results of the Dieblod & Yilmaz [11] spillover index denote that the expected investment returns and volatility transmission to Asian financial markets were more sensitive to and influenced by transmission from other markets during the GFC than in the COVID-19 and Ukrainian conflict periods. The outcomes of the generalized impulse response analysis reveal that it can be noticed that Asian markets exhibit an immediate response to shock in other markets. Also, an impulse in EU and US markets seems to have initiated a positive response in all Asian indices. The financial markets in Asia became more less sensitive to shocks in each other's and in international financial system, and this in turn carries an important implication for investors and policy makers where investors nowadays have considerable potentials to diversify their investment portfolios across Asian and developed indices to achieve between risk and return trade-offs. Moreover, the policy markets in Asia need to apply fully-fledged policies in order to enhance the long-term amalgamation with international financial systems to allow for a more efficient flow of investment capital and FDI. This study opens the door, as we believe to further research and comparison among various types of crises on financial markets in order to revisit the financial amalgamation of these avenues with the rest of the globe in order to equip investors and policy makers with more comprehensive evidence on the sources and directions of future uncertainties.

6- Declarations

6-1- Author Contributions

Conceptualization, A.K.; A.J., and S.A.; methodology, S.A.; W.B., and A.J.; software, S.A.; formal analysis, S.A., and A.J.; resources, A.K., and W.B.; data collection, S.A., and W.B.; writing—original draft preparation, S.A., A.J., and A.K.; writing—review and editing, A.J., W.B., A.K., and S.A.; supervision, A.J. and S.A. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

In the study, data were obtained from the DataStream. The data cited in this study are not publicly available. However, the corresponding author can provide the data upon request.

6-3- Funding

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6-4- Institutional Review Board Statement

Not applicable.

6-5- Informed Consent Statement

Not applicable.

6-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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