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Volatility Spillovers among Emerging Asian Stock Markets along Chinese Belt and Road Initiative: Evidence from Diebold and Yilmaz (2012) Spillover Index Method

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Abstract

This paper investigates the dynamic volatility spillovers among emerging Asian stock markets which are active members of Chinese Belt and Road Initiative from 2005-2023 through spillover index framework based on generalized forecast error variance decomposition proposed by Diebold and Yilmaz (2012). Using daily return based realized volatility proxies and 200-days Rolling Window VAR framework, we found that more than half of the market volatility is due to cross market spillovers. Moreover, Malaysian and Philippine stock markets acted as major volatility transmitters and Sri Lanka and Pakistan equity markets appeared as major volatility spillover receivers. Additionally, volatility significantly amplified during major global events like GFC, Chinese stock market crash and Covid-19 Pandemic elevating systemic risk and diminishing the benefits of regional portfolio diversification.

Keywords: Belt and Road Initiative, Covid-19 Pandemic, Global Financial Crises, Stock Markets, Volatility Spillovers.

1. Introduction

Financial interdependence and volatility spillovers among emerging markets have been key topics in international finance research, especially within the context of Belt and Road Initiative started by China in 2013. The Interdependence of BRI countries through their equity markets reflect both cross border capital flows and shared vulnerabilities to cross markets shocks. However, despite growing attention of researchers towards volatility in Asian financial markets, very few studies has addressed dynamic volatility spillovers among BRI-linked emerging markets using Diebold and Yilmaz (2012) spillover framework.

This study investigates the static as well as dynamic volatility connectedness among 10 emerging Asian stock markets of Turkey, India, Sri Lanka, Malaysia, Indonesia, Pakistan, Philippine, Thailand, China and Vietnam over the period 2005-2023 using daily data on benchmark stock indices analyzed through Diebold and Yilmaz (2012) spillover index. Main aims of the study are, to capture the direction and magnitude of the volatility spillover overtime, to identify net transmitters and net receivers of volatility spillovers, to evaluate the evolution of total spillovers amid 2008 global financial crises, 2015 Chinese stock market crash and Covid-19 Pandemic.

This study contributes to the existing literature on three main fronts: first, it focused BRI linked emerging equity markets which are not fully explored in dynamic spillover analysis. Second, it uses daily frequency data over a long span of period almost 2 decades enabling a rich investigation of temporal patterns. Third, it employed network visualization tools to understand inter-market linkages, providing actionable insights to investors and fund managers regarding volatility transmission and systemic risk.

2. Literature Review

Over the past few decades, volatility spillovers among stock markets have received enormous attention from academia and research (Khan, Yusoff and Khan, 2014). Early studies of Errunza and Losq (1985), King and Wadhwani (1990) and Cheung and NG (1992) investigated cross- market transmission of shocks using granger causality tests paving the way for later developed multivariate volatility frameworks. Diebold and Yilmaz (2009, 2012) introduced VAR based forecast error variance decomposition method to measure volatility spillovers which is widely adopted across different financial markets and asset classes. Chow (2017) applied the same method to UK, US and Asian financial markets and shows that, market openness is correlated with vulnerability to shocks and spillover persisted in post crises period.

Furthermore, Su and Liu (2021) used GARCH and granger based methods in investigating sectoral spillovers in Chinese stock markets and found notable spillovers during Covid-19 Pandemic. Recently, Fatima, Gan and Hu (2022) used the spillover index framework to investigate volatility spillovers among Asia Pacific equity markets. Yousaf *et al.* (2022) combined GARCH approaches with wavelet transform to study spillovers across asset classes during different crises. Moreover, Nurfaiz and Chalid (2022) found that Southeast Asian Indices of Indonesia i.e JKSE and Malaysian KLSE shows greater response to US markets during Covid-19 Pandemic.

Bilgin *et al.* (2024) found strong volatility spillover effects between Islamic stock markets and energy markets of Asia. Joshi et al. (2021) also studied Asymmetry in volatility spillovers among Asian emerging markets using VAR-GARCH methods. Oh and Kim (2024) found channel of financial contagion between US and Chinese markets during trade

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war. Das and Nandi (2022) investigated volatility spillovers between India and G7 countries through BEKK and DCC-GARCH models during Covid-19 Pandemic.

Caporin *et al.* (2021) shows asymmetric and time-frequency spillover among commodity markets using high frequency data. Niu and Cao (2024) shows deep spillovers from metal futures to Chinese equity markets using DCC-GARCH and spillover index method. Similarly, Vo and Tran (2020) studied volatility spillovers among US and ASEAN emerging markets. Arouri *et al.* (2011) studied emerging markets of Saudi Arab for showing Oil- stock volatility. Ali, Shah and Khan (2025) investigated the return spillovers among emerging Asian markets and found moderate interdependence across the region. Dynamic connectedness and volatility spillovers among BRI linked emerging Asian equity markets have not been extensively investigated. This study contribute significantly to existing literature by investigating both dynamic and static volatility spillover measures through Diebold and Yilmaz (2012) spillover index method among emerging Asian stock markets using daily data from 2005-23.

3. Data and Methodology

This study has used daily closing prices of national stock indices of Turkey (BIST), India (BSE), Sri Lanka (CSE), Malaysia (KLCI), Indonesia (JKSE), Pakistan (KSE), Philippine (PSEi), Thailand (SET), China (SHCOM) and Vietnam (VNI) over a period from 2005-2023. These emerging Asian countries are active partners in Chinese Belt and Road Initiative. Daily frequency data is used as it captures significant fluctuations in volatility. It also enables the identification of dynamics of rapid spillover transmissions especially during crises episodes. Prices are converted into continuously compounding returns series by taking its natural log and deviations from mean returns are squared to compute realized volatility which is a standard practice for volatility clustering in financial econometrics research (Diebold and Yilmaz, 2012 & Caporin et al., 2021).

$$Rt = \ln(Pi / Pi\text{-}1)$$

Where ***Rt*** shows returns, ***ln*** is natural log, ***Pi*** represent today's price and ***Pi-1*** shows lag price or previous day's price.

Figure 1 shows the graphical presentation of daily return based volatility series of 10 national stock indices of emerging Asian countries along BRI covering Turkey, India, Sri Lana, Malaysia, Indonesia, Pakistan, Philippine, Thailand, China and Vietnam approximately for the period 2005 to 2023.

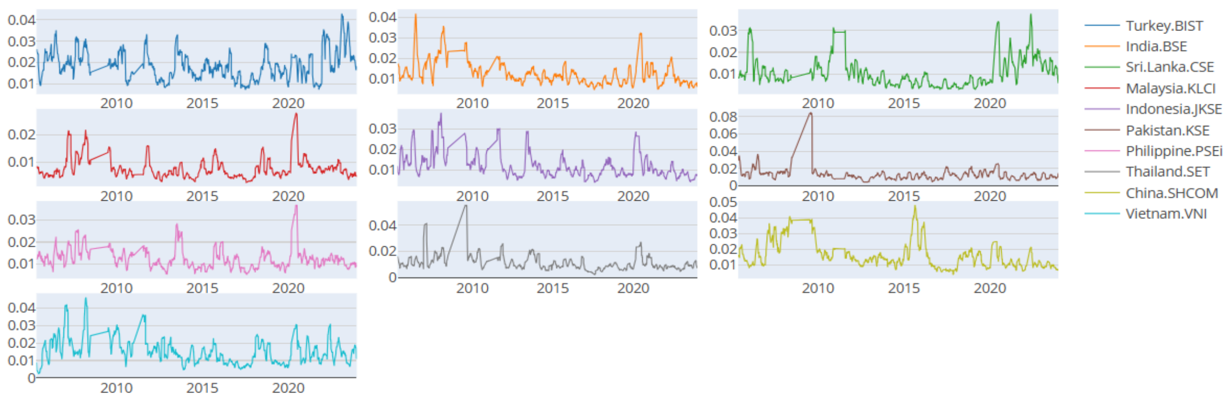

Figure 1 Graph of Volatility Series of Emerging Asian BRI Stock Markets

Diebold and Yilamz (2012) spillover index framework has been used for analysis of data. This method uses generalized forecast error variance decomposition (GFEVD) from Vector-Autoregressive (VAR) model to measure the magnitude as well direction of volatility

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spillovers. In their preliminary work, Diebold and Yilmaz (2009) used orthogonalized decomposition based on Cholesky Factor Identification (CFI) which was dependent on variable ordering. The generalized approach based on Pesaran and Shin (1998) produces variance shares that are invariant to variable ordering. The total connectedness index (TCI) captures the proportion of forecast error variance which is caused by cross market spillovers. Directional spillovers "TO' and "FROM" represent how much volatility spillover each market is transmitting to other markets and how much spillover each market receives from other markets respectively. Net spillovers classify markets into net transmitters or receivers. These are calculated as the differences between TO and FROM directional spillovers. Due to its simplicity and rigorous nature, the spillover index framework is widely used in finance literature.

To quantify spillovers, a vector Autoregression (VAR) model of order p was estimated:

$$\mathbf{R}_t = \sum_{i=1}^{p} \mathbf{A}_i \mathbf{R}_{t-i} + \varepsilon_t$$

Where Rt is the N×1 vector of returns volatilities at time t, Ai are parameter matrices, and εt is a vector of innovations. The generalized FEVD is invariant to the ordering of variables and defined as:

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

Where Ψh represents the moving average coefficients, Σ is the variance-covariance matrix of errors, and σjj is the standard deviation of the error term for variable j. The variance decompositions were normalized so that the sum across all sources of spillovers equals 100% for each market:

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{j=1}^{N} \theta_{ij}(H)} \times 100$$

The overall degree of return connectedness in the system:

$$TSI = \frac{\sum_{i,j=1, i\neq j}^{N} \tilde{\theta}_{ij}(H)}{N} \times 100$$

The spillovers transmitted from market i to all other markets (TO), and received by market i from all others (FROM):

$$TO_i = \sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ji}(H)$$

$$FROM_i = \sum_{j=1, j\neq i}^{N} \tilde{\theta}_{ij}(H)$$

The difference between spillovers transmitted and received:

$$NET_i = TO_i - FROM_i$$

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We used a Rolling Window analysis based on 200-days Rolling Window for capturing time varying nature of volatility spillovers. Whereas static spillover tables provides a scalar quantity of total directional and net spillovers, dynamic connectedness helps in tracing how systematic linkages among markets evolve over time or intensify during crises periods. We also visualized the net directional spillovers through network plots for effective interpretation. A network plot consists of nodes and edges. Whereas nodes are dotes representing a particular stock market, the edges are arrows pointed towards nodes. The size of the node and thickness of edge determine the magnitude of spillover being transmitted or received.

4. Results and Discussion

Results are presented in three main forms; Averaged Dynamic Connectedness Table, Dynamic Total Connectedness Graph and Network Plot Interpretation.

4.1 Averaged Dynamic Connectedness Table

Table 1 represents the averaged dynamic connectedness among 10 emerging Asian equity markets over the period 2005-2023. Results reveal clear heterogeneity in volatility transmission across regional markets. The total connectedness index is equal to 58.42% which indicates moderate to high interdependence, paving the way for volatility shocks to spill across the region in a meaningful way. The significantly high TCI value means that more than half of the forecast error variance is explained by cross market spillovers rather than idiosyncratic shocks. Regarding directional spillovers, Philippine and Malaysian equity markets appeared as the dominant net transmitters of volatility spillovers shocks. Philippine PSEi transmit 75.28% shock to other markets and receives 59.68%, which results in net positive valve of +15.60 which is highest among all markets in the sample making it top net transmitter. Similarly, Malaysian KLCI transmits 67.14% against 59.23% from others, resulting in a net positive spillover of +7.91, making it the second largest net transmitter.

On the other side, Sri Lanka and Pakistan equity markets appeared top net recipients of volatility spillover shocks. Sri Lankan CSE transmit 41.91% to other markets and receives 58.84%, resulting in a large net negative value of -16.94, making it the top net receiver. In the same manner, Pakistan KSE and Indonesian JKSE with a net value of -5.82 and -4.88 respectively appeared as net receivers of spillover shocks.

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Table 1 Averaged Dynamic Connectedness Table for Volatility Spillover from 2005-2023

	Turkey.BIST	India.BSE	Sri.Lanka.CSE	Malaysia.KLCI	Indonesia.JKSE	Pakistan.KSE	Philippine.PSEi	Thailand.SET	China.SHCOM	Vietnam.VNI	FROM
Turkey.BIST	46.05	7.31	3.98	6.24	4.83	5.42	10.36	5.35	5.66	4.79	53.95
India.BSE	5.49	34.73	4.90	6.83	5.75	6.51	9.98	6.53	8.37	10.91	65.27
Sri.Lanka.CSE	5.25	5.88	41.16	8.80	4.67	6.89	7.16	6.29	6.59	7.32	58.84
Malaysia.KLCI	6.00	4.95	5.43	40.77	5.44	7.41	10.05	6.97	4.73	8.24	59.23
Indonesia.JKSE	4.84	7.53	3.59	5.18	47.56	5.35	5.23	7.41	5.56	7.75	52.44
Pakistan.KSE	5.18	8.66	5.70	8.37	5.17	37.87	8.79	7.17	6.50	6.57	62.13
Philippine.PSEi	6.94	7.62	3.94	9.35	4.46	6.16	40.32	7.40	7.75	6.05	59.68
Thailand.SET	6.90	8.72	3.87	7.56	5.24	7.15	9.49	39.79	5.26	6.03	60.21
China.SHCOM	5.13	5.92	5.20	6.60	5.67	6.20	6.20	5.14	46.16	7.79	53.84
Vietnam.VNI	5.63	6.03	5.29	8.22	6.33	5.22	8.02	8.13	5.76	41.38	58.62
TO	51.36	62.62	41.91	67.14	47.57	56.31	75.28	60.40	56.17	65.45	584.20
Inc.Own	97.42	97.35	83.06	107.91	95.12	94.18	115.60	100.19	102.34	106.83	cTCI/TCI
NET	-2.58	-2.65	-16.94	7.91	-4.88	-5.82	15.60	0.19	2.34	6.83	64.91/58.42
NPT	4.00	5.00	0.00	6.00	3.00	3.00	8.00	4.00	6.00	6.00	

India and turkey also shares net negative values showing that they also absorb more shocks than they transmit to other markets in the system. These findings are consistent with results of Vo & Tran (2020) and Joshi *et al*. (2024) where smaller and less integrated markets absorb volatility shocks while other markets appears as volatility hubs due to their size, openness and investor connectivity.

4.2 Dynamic Total Connectedness Graph

Figure 2 shows the dynamic total connectedness graph showing volatility spillovers among emerging Asian equity markets along BRI during the period 2005-2023. Pronounced fluctuations can be seen during global and regional crises episodes. For the period before 2008, the index fluctuates around 50% reflecting moderate interdependence with occasional upticks. The first significant surge can be seen during 2008-09 global financial crises sending the total spillover to more than 80 % consistent with the literature on crises induced contagion of Aloui, Aissa and Nguyen (2021) and Yousaf and Hassan (2019). Following the post crises stabilization, another significant rise can be seen during 2015-16 period carrying total spillovers to 75% level. This can be attributed to regional turbulence in Chinese stock market known as Chinese Stock market crash in the literature.

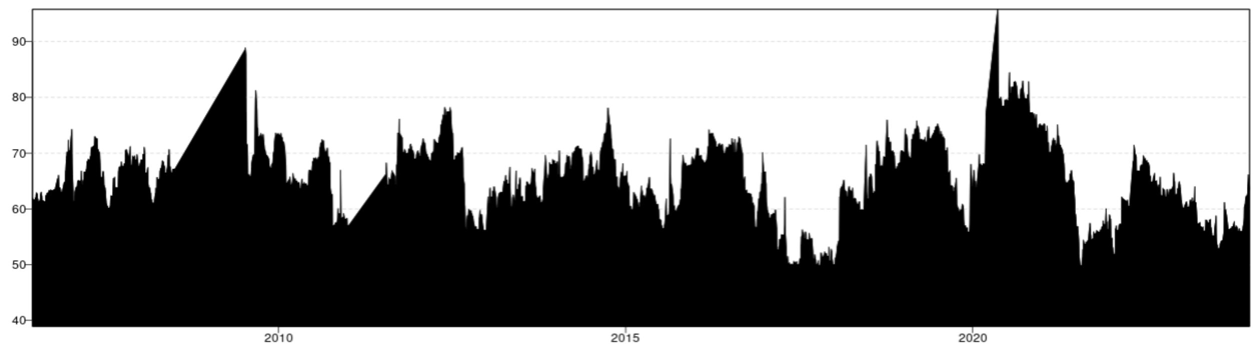

Figure 2 Dynamic Total Connectedness Graph for Volatility Spillovers for the period 2005-2023

The highest peak in the index can be seen during Covid-19 Pandemic of 2020 pushing index to more than 90%, the highest ever recorded leading to significant financial

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contagion. These results are consistent with findings of Aslam et al. (2020, 2021), Ali et al. (2020) and Barro et al. (2020) where pandemic induced systemic shocks reduced the benefits of diversification. In the post-Covid period, the index declined, however still remain higher as compare to pre-pandemic level.

4.3 Network Plot Interpretation

Network visualization supports the net connectedness with more structural clarity. Figure 3 shows network visualization plot for volatility spillovers. The size of node provides information about level of volatility spillover. Malaysia, Philippine and India with larger node sizes and thick outwards going edges exhibited their dominance in volatility spillover transmission. These market occupied central position in volatility spillover network plot. Moreover, Sri Lankan and Pakistani equity markets receive more thick edges showing their net receiver positions. The network confirms that all markets are not equally important in spillover transmission showing that volatility transmission is asymmetric.

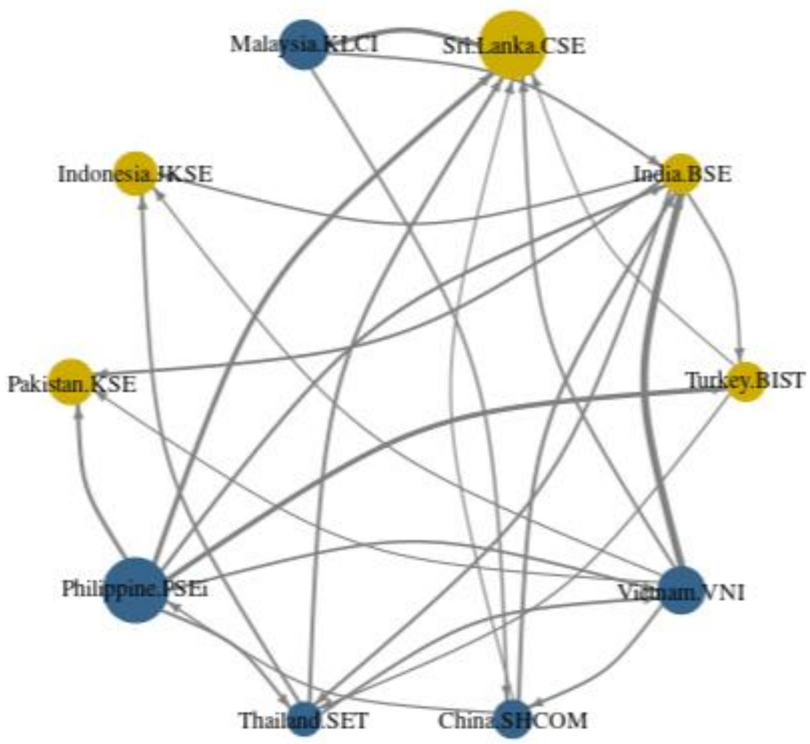

Figure 3 Volatility Spillovers Network Plot

5. Implication for Investors and Policy makers

This paper adds multiple useful insights to the existing literature on contagion and information transmission. First, the high value of total spillover index and its dynamic variation during crises period shows that emerging Asian BRI equity markets are not isolated from the regional and global system. This signal to contagion effect which emphasizes that interconnectedness paves the way for increased systemic risk during turbulent periods which in return diminishes the opportunities for portfolio diversification.

Second, the identification of net transmitters and receivers has practical implications. Large markets due to their structural properties of deeper liquidity and strong foreign investor's participation acts as volatility centers, allowing them to influence other markets disproportionately. For investors, planning to construct regional portfolios, may take into account the position of volatility hubs. Diversification strategies must consider the directional connectedness in order to prevent underestimations of spillover risk.

Third, Investors should not rely on static assessment of markets only, it can be misleading. Dynamic measure are equal important to assess the episodic nature of interdependence and the possibility of changing transmitter-receivers roles. For policymakers, the results highlight the significance of cross-borders and regional economic coordination. Regulators in recipient markets like Pakistan and Sri Lanka should closely watch volatility hubs and consider early warning signs to prevent their domestic markets from contagion and pandemic related shocks.

Finally, the findings of this study suggest that financial integration can enhance economic development; however it can prove a channel of potential risk transmission. Policy makers shall not consider the benefits resulting from financial integration but also the shared risk management framework.

6. Conclusion

This paper investigates the dynamic volatility spillovers among emerging Asian equity markets which are active members of Chinese Belt and Road Initiative from 2005-2023 through Spillover Index framework based on generalized forecast error variance decomposition proposed by Diebold and Yilmaz (2012). Using daily return based realized volatility proxies and 200-days Rolling Window VAR framework, it was found that more than half of the market volatility is due to cross market spillovers. Moreover, Malaysian and Philippine acted as major volatility transmitters and Sri Lanka and Pakistan appeared as major volatility spillover receivers.

Additionally, volatility significantly amplified during major global events like GFC, Chinese stock market crash and Covid-19 Pandemic elevating systemic risk and diminishing the benefits of regional portfolio diversification. For Investors, the study suggests that volatility hubs and directional connectedness shall be considered for efficient portfolio management. To Policy-makers, the study advises to build mechanisms and make strategies for regional coordination, risk mitigation and volatility monitoring. Future researchers may investigate macroeconomic fundamentals that drive volatility spillovers, employ high frequency preferably intraday data for more accurate inferences and apply frequency based asymmetric connectedness tools to explain the upside vs. downside risk transmissions.

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