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Assessing the Impact of Geopolitical Crises on Global Financial Markets: Insights from the Novel TVP-VAR Model

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Abstract The aim of this study is to examine the impact of the recent geopolitical crisis on global equity, commodity, and cryptocurrency markets over the period from January, 2021 to December 2023. Based on the TVP-VAR, this study examines the dynamic connectedness among the variables of interest. The results revealed an increase in volatility connectedness among the markets during the crisis periods compared to the period before crisis. The equity market indices served as the main transmitters of volatility, while the commodity markets were the net receivers. In addition, bitcoins served as risk transmitters throughout the entire period and in the two sub-periods. Chinese market exhibited as the most resilient market during the geopolitical crisis. Furthermore, the commodities market (oil and gold) exhibited characteristics of safe-haven assets and hedging abilities during the crisis. The study revealed no indication of bitcoin serving as a safe-haven asset within the cryptocurrency market. These results carry substantial implications for investors, fund managers, and policymakers, highlighting the importance of crafting strategies and policies informed by the study's findings to effectively navigate future crisis episodes.

Keywords: Geopolitical Crises, Global Financial Markets, TVP-VAR, Volatility Spillovers

JEL Classifications: F21, G01, G11, G15

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I. Introduction

The global health crisis of the COVID-19 pandemic severely disrupted the world economy, surpassing the impact of the Global Financial Crisis (GFC) of 2008 due to its widespread effects on various industries, economies, and assets (Li et al., 2022). As the global economy began to recover from the devastating impact of COVID-19, two significant geopolitical events emerged: the Russian invasion of Ukraine on February 22, 2022, and the Israel-Palestine conflict on October 7, 2023. These events are of particular concern as the affected countries are among the major exporters of oil and gas, soyabean, fertilizers, food grains, and certain metals, potentially leading to a global economic slowdown (Fahad et al., 2023).

Volatility transmissions among financial markets is a key factor, and its proper management

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is crucial for investors to avoid losses. With an increase in volatility connectedness, shocks will transmit among the markets, disturbing the risk and returns in those markets. Investors seek to minimize risk by investing in assets that are uncorrelated or weakly correlated and have varying risk levels. The literature has highlighted that equity market integration enhanced due to turbulent periods including the GFC and the global health crisis of COVID-19. Investors shifted their attentions to other assets such as oil, gold, cryptocurrencies and agricultural commodities which promised a safe-haven, hedge and diversifiers services in various markets. To manage risks, investors employ various strategies, including diversification, hedging, and investing in safe-haven assets. While diversification and hedging strategies can be used at all times, safe-haven assets are primarily considered during turbulent market episodes. In normal times, assets with weak associations can serve as diversification or hedge assets, whereas during crises episodes interconnections among the markets increases and investors turn to safe-haven assets with negative or weak correlations especially during the crisis periods (Yousfi et al., 2024).

Market volatility is a critical factor, and effective management is essential for investors to mitigate losses. A higher degree of volatility connections means that shocks in one market can spread to others, impacting risk and returns across those markets. Investors aim to mitigate risk by investing in low or uncorrelated assets having varying risk levels. The literature indicates that equity market integration has intensified during turbulent periods such as the GFC and the COVID-19 pandemic. Consequently, investors have diversified their portfolios to include assets such as oil, gold, cryptocurrencies, and agricultural commodities, which offer safe-haven, hedging, and diversification benefits across various markets.

Existing literature identified several assets that serve as hedges, diversification tools, and safe havens for financial markets during crises. These assets are typically grouped into three categories: financial assets, commodities, and the recently emerged cryptocurrencies. A number of existing studies found that commodities and cryptocurrencies has proven effectiveness as hedge and safe-haven assets during crises (Bouri et al., 2020; Shahzad et al., 2020; Mensi et al., 2023; Yousfi et al., 2021). Other studies have found that oil and other commodity futures have also served as safe-havens and hedge assets (Basher & Sadorsky, 2016; Shahzad et al., 2019).

The demand for safe-haven and hedge assets particularly increases during crisis periods due to heightened integration and increased risk transmissions among global financial markets, indicating the emergence of financial contagion. According to (Forbes & Rigobon, 2002), financial contagion result in increased overall linkages among financial markets during turmoil episodes, leading to risk transmissions among markets. Numerous studies have highlighted financial contagion across global markets during various crisis periods, including the GFC, Eurozone debt crisis (2014), COVID-19 pandemic and war periods (Akhtaruzzaman et al., 2021; Khan, 2024; Kim et al., 2015; Mokni & Mansouri, 2017).

Recently, the financial and economic systems have faced various crisis episodes due to the

COVID-19 health crisis, the war between Russia and Ukraine, and the more recent crisis between Israel and Palestine. These crises have influenced the behavior and performance of the global financial system. A large number of studies have focused on the impact of these crises on global financial and economic systems. As predicted by (Izzeldin et al., 2023), the conflict between Russia and Ukraine could potentially impact the global economy more significantly than the COVID-19 crisis, given the substantial role of these nations in global exports. In addition, most of the existing studies argued that crises had heightened market linkages and induced higher risk transmissions, presenting new challenges to investors in their portfolio management and risk mitigation. Most of these studies suggest that investors should consider alternative assets with less pronounced connections with equities, especially during turbulent periods.

The interconnectedness among the global financial markets has been a topic of significant importance for policy makers, investors and fund managers. The significance of such research has recently gained more attention since the GFC, COVID-19 pandemics and the recent geopolitical crisis emerged due to Russian invasion in Ukraine. (Adams & Glück, 2015) argued that investors shifted their fund flows towards commodities markets to rebalance their portfolios in the early 2000s. This flow of funds towards commodities markets enhances the integration in financial markets termed as '*financialization*' (Adams & Glück, 2015). The study of interconnections among the financial markets thus got significant importance among the regulators and policy makers, who design economic policies due to the potential financial contagion. For investors, the information on risk transmissions among the markets carry equal importance who have interest in portfolio diversification and hedging strategies.

More recently, due to the developments in commodities markets, investors seek to diversify their investments by combining various commodities with financial assets. Certain commodities, such as oil, metals, and food grains, serve as primary inputs in the production process, thereby establishing a connection with the stock markets. For instance, a rise in crude oil prices increases production cost in many industries, this in turn results in lower profitability. Specifically, the interconnections among various financial assets have been found to have time-varying characteristics around periods of crisis (Hung & Vo, 2021; JEBABLI et al., 2022; Mensi et al., 2022; Wang et al., 2022).

Based on the discussion of earlier studies in the preceding section, this study identified an important gap in the literature. To the best of the author knowledge, no previous study examined the concurrent impact of the war between Russia and Ukraine and that between Israel and Palestine. The investigation of these geopolitical crises impact on the risk transmission among key financial and commodities markets is a timely and important topic for investigation. The current study therefore, delved in to this important area by examining the impact of recent war crises on various global financial and commodities markets[1]. To achieve the objective

1) The role of these assets in volatility transmissions have largely been investigated by various existing studies during

of the study, this study employed the novel TVP-VAR extended joint connectedness approach developed by (Antonakakis et al., 2020), and investigating important stock markets of China, MSCI world, UK and the U.S., in conjunction with commodities and cryptocurrencies markets[2]. The current paper aims to investigate the impact of the more recent geopolitical conflicts on volatility transmissions among these pivotal equity, commodity and crypto markets. Through this analysis, this study attempt to shed light on the broader implications of geopolitical crises on financial and commodity landscapes.

The current study will thus make important contributions to the existing literature in various fronts. First, this is a first study to examine the two most significant crises periods impact on the risk spill overs among the most important global markets[3]. The implications and guidelines based on the findings will help a wide range of stakeholders in their decision-making process regarding assets allocation and portfolio diversification. Second, most of the existing studies in the literature has focused on single crisis episodes, this study is investigating concurrently two war events and their impact on the important global market's volatility connections. Third, the application of a novel TVP-VAR approach for investigating joint connectedness has several advantages over the traditional approaches examining linkages. These advantages include the obviation of setting a window size; reducing the susceptibility to outliers, prevention of data loss, adaptability to alterations in parameters, and enabling a more accurate calculation of the Generalized Forecast Error Variance Decomposition (GFEVD) (Balcilar et al., 2021). Finally, this paper has captured the impacts of the two war crises on the dynamic total risk spill overs. To the best of the Author's knowledge, no previous study has yet scrutinized the impact of the two important geopolitical event concurrently on the financial and commodities markets. This study is thus providing fresh evidence by providing more timely decision-making references for various stakeholders.

The balance of the paper is organized as follows: Section (2) highlights the relevant literature review. Section (3) reports the sources of data and methodological techniques applied. Section (4) highlights the empirical results and discussions. Finally, Section (5) concludes the paper.

II. Literature Review

Geopolitical crises encompass threats, occurrences, and escalations of tensions related to war, terrorism, and any conflicts between states, as well as political factors affecting peace

other crises periods including those of GFC, the recent health crisis of COVID-19.

2) They investigated oil and gold as representatives of the commodity market and Bitcoin as a proxy for the crypto market.

3) With the exception of just few studies such as (Khan, 2024), most of the existing studies has focused on one crisis event over a short span of time.

processes in international relations (Caldara & Iacoviello, 2022). The occurrences of these crises impacted financial liquidity and investor sentiment (Asai et al., 2020; Su et al., 2019; Tiwari et al., 2021), resulting in increased volatility in financial markets and subsequent transmission of financial risk across global financial markets.

The global economy witnessed various crises episodes in the last five years starting from the global health crisis of COVID-19 pandemics, the war between Russia and Ukraine and the more recent tension between Israel and Palestine. These crises have impacted global financial markets, including capital markets, commodities markets, energy markets, and the foreign exchange markets. The recent conflicts between Russia and Ukraine, as well as between Israel and Palestine, have raised concerns among scholars and policymakers regarding geopolitical risks. Previous researchers have termed these events as "black swan" events, having significant impacts on the financial markets. (Zheng et al., 2023) suggested that within the framework of global financial market integration, the volatility induced by geopolitical risks can readily result in financial risk spillover across key financial markets. Moreover, various studies have analyzed the influence of the recent health crisis caused by COVID-19 on global financial markets. For instance, focusing on the global stock markets (Basuony et al., 2022) investigated major stock market indices of Brazil, China, Germany, India, Italy, Russia, Spain, UK, and the U.S., for a time period spanning from January 1, 2013 to December 31, 2020. Their findings indicated that asymmetric volatility among the markets increased across all markets during the pandemic period. They further argued that bad news of deaths had more pronounced impact on the volatility spillovers as compared to the good news of recoveries. (Cheng et al., 2022) investigated daily data for 19 stock markets from different continents. Their results indicated that overall volatility connections among the stock markets increased due to the outbreak of COVID-19 pandemics and remained high throughout the year 2020. The overall connectivity among the markets from different continents remained high during the pandemic period. In contrast to the findings of (Contessi & De Pace, 2021) who found volatility spillovers from Chinese to European markets, (Cheng et al., 2022) found that China remained disconnected from the global stock markets until late November 2020. They concluded that China being the epicenter for the pandemics was not the main source of volatility transmissions during COVID-19 crisis.

In the more recent years, integration among global markets increased due to more trade linkages. In addition, during the past few decades, investors' attention shifted towards alternative investment assets due to various crisis. These in turn resulted in heightened interconnections among global asset markets especially in turmoil periods. Particularly, the developments and innovations in commodities markets resulted in quick spread of risks between the commodity and financial markets. Due to higher instability in financial markets, investors and other stakeholders recognized commodities as an important element of portfolio investment (Yang et al., 2020).

These links were more pronounced during various crisis episodes including the GFC, the COVID-19 pandemics and the more recent geopolitical crisis. These association among the commodities and financial markets attracted the focus of investors, fund managers and policy makers to continuously monitor stock and commodity markets changes to make a well-informed investment decision. Hence, this study explores the potential relationship between equity and commodities markets during the recent geopolitical crises arising from the Russia-Ukraine war and the Israel-Palestine conflict over a more recent timeframe. The possible integration among the markets due to these crises would mean that negative shocks in one market will have an adverse impact on the investor's returns in other markets. (Mensi et al., 2019) argued that analysing volatility spillovers between markets is a major issue for investors especially during crisis.

A strand in the recent literature investigated the dynamic relationships among various assets including the stock markets, commodities markets and cryptocurrencies markets. For example, investigating the dynamic linkages among commodities (gas, gold, oil, platinum, and silver) and equity markets of the G7 and BRIC countries, Alam et al., (2022) found a significant impact of the crisis due to war between Russia and Ukraine. By utilizing the TVP-VAR framework for analysis, they revealed that gold and silver were the recipients of shocks from the rest of the markets. Moreover, the equity markets of Brazil, Canada, China and the U.S., were found to be the net receivers of shocks from the rest of the markets. Their findings indicated that the impact of the recent war crisis was different from the health crisis where U.S., market was the main transmitter of risk (Khan, 2024). Analyzing the impact of the Russia-Ukraine war on various global markets including stocks, cryptocurrencies, and commodities, (Li, 2023) discovered a substantial increase in spill overs among these markets during the war period. Their findings indicated that the French and German stock markets acted as net volatility transmitters, driving global market risk, while the Japanese stock market served as a net volatility recipient. Before the conflict, the U.S. stock market transmitted volatility, but it shifted to being a receiver afterward. Similarly, the role of the Chinese market changed from being a receiver to a transmitter during the war period. These findings underscored the diverse effects of international crises on stock markets, highlighting variations in market sensitivity to geopolitical events in an increasingly interconnected global economy.

Izzeldin et al. (2023) examined the effects of significant crises, including financial (GFC), health (COVID-19), and geopolitical (Russia-Ukraine war) crises, on global financial markets[4]. They examined the synchronization, duration, and intensity of the war compared to other crises. Metrics of intensity revealed that, in contrast to the GFC and COVID-19 pandemic, the Russia-Ukraine war had a lesser impact on global financial markets. They proposed that this could be attributed to the anticipation that the war would not be prolonged. (Mitsas et al., 2022)

4) In particular the study examined 25 equity markets and 20 commodities over the three crises periods including the GFC, COVID-19 pandemic and the Russia-Ukraine war periods.

argued that the geopolitical risk and threat had a negative impact on gold, crude oil, platinum and silver futures returns and exert negative impact on geopolitical acts. Conversely, crude and heating oil, platinum, and sugar futures returns were negatively affected by geopolitical risk. They concluded that commodities were more suitable for diversification against various geopolitical risk components. (Gong & Xu, 2022) employed a TVP -VAR-SV model from June 2008 to December 2020 and found that geopolitical risk negatively impacted precious metals and industrial metal commodity markets. (Chen et al., 2022) found that gold and silver served as hedge and safe-haven assets during extreme geopolitical crisis.

Recent literature underscores the significant impact of crises, such as the pandemic and geopolitical tensions, on derivative pricing, hedging strategies, diversification opportunities, and commodity portfolios. These events also influence food security, financial stability, consumer spending, inflation, and economic activities. Consequently, it is imperative for policymakers and investors to keep in mind the dynamics of commodity markets and risk spillovers amidst geopolitical conflicts like the Russia-Ukraine and Israel-Palestine crises.

The existing literature highlights the intensification of market integration and volatility spread across various crises. This phenomenon has led investors, fund managers, and policymakers to explore commodities and cryptocurrencies markets for their hedging potential and safe-haven characteristics amidst heightened risk transmissions in stock markets. However, research on recent geopolitical crises remains limited, with most studies focusing on single crisis periods. This study aims to address this gap by concurrently examining the impacts of the recent conflicts between Russia and Ukraine and between Palestine and Israel. Given their significant roles in the global economy, understanding the effects of these turmoil periods on global financial markets is crucial for various stakeholders. Furthermore, this study encompasses vital global financial markets, including equities, commodities, and cryptocurrencies, which have been overlooked in previous research. By investigating the combined impacts of recent geopolitical crises on these diverse asset markets from January 5, 2021, to December 18, 2023, this paper seeks to contribute to the literature and provide valuable insights for investors and policymakers.

III. Data and Methodology

This study investigates the impact of the recent geopolitical crisis on volatility spillovers effects on important global stock markets, commodity markets and cryptocurrency market. Daily closing price data are used for China (Shanghai Stock Exchange Composite Index SSEC), UK (FTSE), the U.S., (S&P 500), MSCI World index (World), West Texas Intermediate (WTI) Crude oil prices (oil), gold prices (gold) and Bitcoins (BTC). The data period is spanning from January 5, 2021 to December 18, 2023 encompassing the crisis periods of Russia-Ukraine

war and the Israel-Palestine war. The data was sourced from investing.com. The selection of variables was based on their global significance as S&P 500 and the MSCI World index represents the global stock markets. FTSE is selected due to its prominent role in the European region. Chinese market is selected based on its vital role as an emerging market not only in the Asian region but globally. Oil, gold and cryptocurrency markets are utilized due to their vital role in the global financial system serving as safe-haven and hedging tools during crisis periods (Shahzad et al., 2020). The selection of the sample period was based on the time period covering the time of both pre- and during crisis periods started with the Russian invasion in Ukraine in February 2022. To achieve the objective of the paper, the entire sample period is analyzed along with two sub-periods of pre-and during war sample periods. The cut-off date is implemented as February 24, 2022 denoting the official start date of the Russia-Ukraine war[5].

To analyse the variables, the price series of all variables are converted into returns using the following formula:

$$R_t = \mathrm{Ln}\left(\frac{P_t}{P_{t-1}} \right) \tag{1}$$

In this context, R_t represents the daily closing at day t, P_t indicates the current price level of the financial asset at the end of day t, P_{t-1} corresponds to the price level of the asset on the preceding day, and Ln denotes the natural logarithm.

This study employs the standard TVP-VAR framework an extension of the method developed by (Diebold & Yilmaz, 2012; Diebold & Yılmaz, 2014), as proposed by (Antonakakis et al., 2020)[6]. The research examines the dynamic volatility connections among the stock markets of China, the UK, the U.S., and the MSCI world index, alongside oil and gold futures representing commodities, and bitcoins for the cryptocurrency market. Unlike traditional methods, the TVP-VAR framework addresses issues of overly smoothed parameters and ensures a robust analysis without discarding valuable observations. The model, selected with a lag of one using the Bayesian Information Criterion (BIC), is expressed as follows:

$$X_t = \beta_t X_{t-1} + \epsilon_t \quad \epsilon_t \sim N(0, S_t) \tag{2}$$

5) The pre-war period started from January 2021 when the world was recovering from the COVID-19 pandemics and vaccines were already announced to control the deadly pandemics from further damages in the form of human lives. This period ended on February 22, 2022 when Russia invaded Ukraine and ended until December 2023 encompassing the impact of the Israel-Palestine war which started on October 7, 2023.

6) This study employed a standard TVP-VAR model that does not incorporate stochastic volatility. The choice of the standard TVP-VAR model was driven by the objective to capture the dynamic relationships among the markets over time, with a primary focus on the changing coefficients. The author believes this approach effectively addresses the research questions related to the time-varying interconnections among the markets studied.

$$\beta_t = \beta_{t-1} + \nu_{t.} \quad v_t \sim N(0, R_t) \tag{3}$$

In equations (2) and (3), X_t, X_{t-1} and ϵ_t represents vectors of endogenous variables with dimensions of $N \times 1$. The parameter S_t represents the time varying variance-covariance matrix with dimension of $N \times N$, β_t is a matrix of VAR coefficients with dimension of $N \times N v_t$; is an intercept vector with $N^2 \times 1$ *dimension.* Finally, R_t is $N^2 \times N^2$ dimension variance-covariance, time varying matrix.

The time-varying parametric vector autoregressive (TVP-VAR) model with a stationary order of (p) can be represented as follows:

$$X_t = \sum_{i=1}^{p} \Omega_{i,t} X_{t-i} + \epsilon_t \tag{4}$$

The dynamic nature of equation (4) is pivotal, and it can be represented as a moving average expression as follows;

$$X_t = \sum_{i=0}^{\infty} A_{i,t} \epsilon_{t-i} \tag{5}$$

Here $\Omega_{i,t}$ and $A_{i,t}$ represent the time-varying coefficients at time *t*, reflecting the evolving nature of the inter-connectedness among the markets.

The core concept behind time-varying coefficients in the vector moving average (VMA) model can be utilized to calculate Generalized Forecast Error Variance Decompositions (GFEVD), as outlined by (Koop et al., 1996) and (Pesaran & Shin, 1998). This methodology ensures the reliability of results, regardless of variable ordering. Following this approach, the H-step ahead forecast error variance decomposition is calculated using the equation as follows:

$$\emptyset_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=o}^{H-1} \left(e_i' A_h \sum e_j\right)^2}{\sum_{h=o}^{H-1} \left(e_i' A_h \sum A_h' e_j\right)} \tag{6}$$

Where Σ: represents the covariance matrix of the error term (ϵ_t) in the model. This matrix captures the variance and covariances of the shocks to the variables in the system.

σjj; is the *j*-th diagonal element of the covariance matrix Σ. It represents the variance of the error term for the j-th variable.

Equation (6) is written in normalized form as:

$$\tilde{\phi}_{ij}(H)=\frac{\varnothing_{ij}(H)}{\sum_{j=1}^{N}\varnothing_{ij}(H)} \tag{7}$$

The GFEVD, as conceptualized by (Diebold & Yilmaz, 2012), quantify the variance of variable i accounted for by variable j, denoted as $\phi_{ij}(H)$, at the forecasting horizon H. Here e^{i} denotes a zero vector with unity value at the ith position, ensuring that $\Sigma_{j=1}^{N}\widetilde{\phi}_{ij}(H)=1$, and $\Sigma_{i,j=1}^{N}\widetilde{\phi}_{ij}(H)=N$.

The Total Connectedness Index (TCI) is formulated based on the GFEVD and is computed using the following equation:

$$TC(H)=\frac{\sum_{i,j=1.\ i\neq j}^{N}\widetilde{\varnothing}_{ij}(H)}{\sum_{i,j=1}^{N}\tilde{\phi}_{ij}(H)}\times 100\ \ with\ \ i\neq j \tag{8}$$

As a result, the primary emphasis is on how market (i) disseminates its impacts to all other markets (j), representing the total directional connections (*to* other) markets:

$$C_{i\rightarrow j}(H)=\frac{\sum_{j=1,j\neq i}^{N}\widetilde{\varnothing}_{ij}(H)}{\sum_{i,j=1}^{N}\tilde{\phi}_{ij}(H)}\times 100 \tag{9}$$

Where $\widetilde{\varnothing}_{ij}(H)$ represents the time-varying impulse response of all other markets (j) to shocks originating from market (i).

Secondly, total directional connectedness (*from* other) markets is calculated as:

$$C_{j\rightarrow i}(H)=\frac{\sum_{i=1,i\neq j}^{N}\widetilde{\varnothing}_{ji}(H)}{\sum_{i,j=1}^{N}\tilde{\phi}_{ij}(H)}\times 100 \tag{10}$$

Where $\widetilde{\varnothing}_{ji}(H)$ represents the time-varying impulse response of market (i) to shocks originating from all other markets (j).

The difference between the shocks sent from market (i) and the gross shocks received from all other markets (j) can be used to determine the net spillovers from market (i) to all other markets (j) as;

$$NC_{ij}=C_{i\rightarrow j}(H)-\ C_{j\rightarrow i}(H) \tag{11}$$

The positive value of NC indicates that market (*i*) is the source of shocks to all other markets (*j*), whereas, a negative value of NC shows that market (*i*) is the receiver of shocks from other markets (*j*).

IV. Results and Discussions

The top panel of the Table 1 highlights the summary statistics whereas, the lower panel shows the results of the correlation analysis. The summary statistics indicate that the average daily returns were positive for all assets except for the Chinese market during the entire sample period which showed a negative daily return. It means that the Chinese market fail to create value for the investors seeking investment during this time period. The cryptocurrency market (bitcoin) and the commodity market (oil and gold) showed the highest level of volatility. The heightened volatility in these markets is observed due to the recent geopolitical crisis. These results align with those of (Kumar et al., 2023), who observed increased volatility in cryptocurrency and commodity markets during the COVID-19 pandemic and the Russia-Ukraine crisis periods. The stock market in UK and China showed lowest volatility levels during the period. The U.S. market volatility level was observed to be highest among the equity markets indicating higher impact of the war-crisis on the U.S. market. The skewness values indicated negatively skewed returns for all markets except the gold market which showed positive skewness value. This shows the unique characteristics of gold during crisis periods. The kurtosis values are all high than the value for normal distribution, indicating leptokurtic distribution having extreme observations in the distribution as compared to normal distribution. The Jaque-Bera (J-B) test confirmed the rejection of the null hypothesis of the normal distribution and indicated that all the returns series deviate from normal distribution. The Augmented Dicky Fuller (ADF) and Phillip-Perron (P-P) highlights the presence of unit root in the level form and stationarity when the series were first-differenced.

The lower panel of the Table 1 indicated the correlation matrix for the markets over the entire sample period. The results shows that the UK and the U.S. markets were the more linked market with the rest of the markets. The table shows that UK market was significantly correlated with the U.S., China and the World market. The U.S. market was correlated with the bitcoin, UK and the oil market. The world market was also correlated significantly with the UK, gold and Chinese market. During the crisis period of war, the static relationship among these markets revealed that commodity markets, in particular, exhibited lower association with global equity markets compared to the interconnection among equity markets themselves. The less pronounced connections among the equity markets with the commodity markets signifies that these commodities might have potential for risk reduction when combined with the equity portfolios

during turbulent periods such as the one investigated in this study.

Table 1. *Summary Statistics, Unit Root tests and Correlation Matrix Over the Whole Period*

	BTC	FTSE	GOLD	OIL	S&P 500	SSEC	WORLD
Mean	0.042	0.021	0.007	0.059	0.033	-0.025	0.021
Std. Dev.	4.041	0.868	2.406	2.496	1.112	0.975	1.044
Skew.	-0.516	-0.473	0.245	-0.629	-0.199	-0.515	-0.587
Kurt.	7.487	6.157	272.5	5.229	4.604	7.496	11.43
J-B	659.7*	338.2*	2261*	203.9*	85.04*	662.1*	2253.3*
ADF	-27.02*	-28.69*	-16.13*	-26.59*	-27.19*	-27.50*	-20.03*
P-P	-27.01*	-28.77*	-40.67*	-26.87*	-27.27*	-28.23*	-24.41*
Correlation							
BTC	1.000						
FTSE	0.057	1.000					
Gold	-0.014	0.037	1.000				
Oil	0.061	0.062	-0.022	1.000			
S&P 500	0.384*	0.121*	0.004	0.146*	1.000		
SSEC	-0.023	0.150*	0.023	-0.002	0.045	1.000	
World	0.015	0.524*	0.384*	0.034	0.071	0.095*	1.000

(*) indicates significance at 1 per cent level.

Figure 1 displays the return series for commodity, equity, and cryptocurrency financial assets throughout the entire sample period spanning from January 2021 to December 2023. The geopolitical crisis periods, namely the Russia-Ukraine invasion on February 22, 2022, and the Israel-Palestine conflicts on October 7, 2023, are marked by dotted red lines. A visual examination of the plots indicates an increase in volatility across all assets during turbulent periods compared to the relatively calmer period before the Russia-Ukraine war. Moreover, the plots reveal volatility clusters, indicating that the geopolitical crisis heightened volatility across all markets. Specifically, the oil market experienced a notable surge in volatility due to the Russia-Ukraine war, as depicted in the plot. One potential explanation for this surge is the significant role of Russia as an oil exporter, which had a pronounced impact on the oil market. Additionally, the imposition of various sanctions on Russia may have disrupted the supply chain, leading to increased oil shocks. Besides the commodities markets, the equity markets also witnessed increased volatility amidst the recent geopolitical crisis. Visual inspection of the plots for Chinese, U.S., UK, and global indices indicates heightened volatility spikes during crisis periods. Moreover, the influence of the Russia-Ukraine war seems more significant in contrast to the Israel-Palestine conflict. One potential explanation is the greater economic significance of Russia and Ukraine, serving as major exporters of oil, gas, and food items, when compared to Israel and Palestine.

Figure 1. Plots of the return series for the sample period from January 2021-December 2023

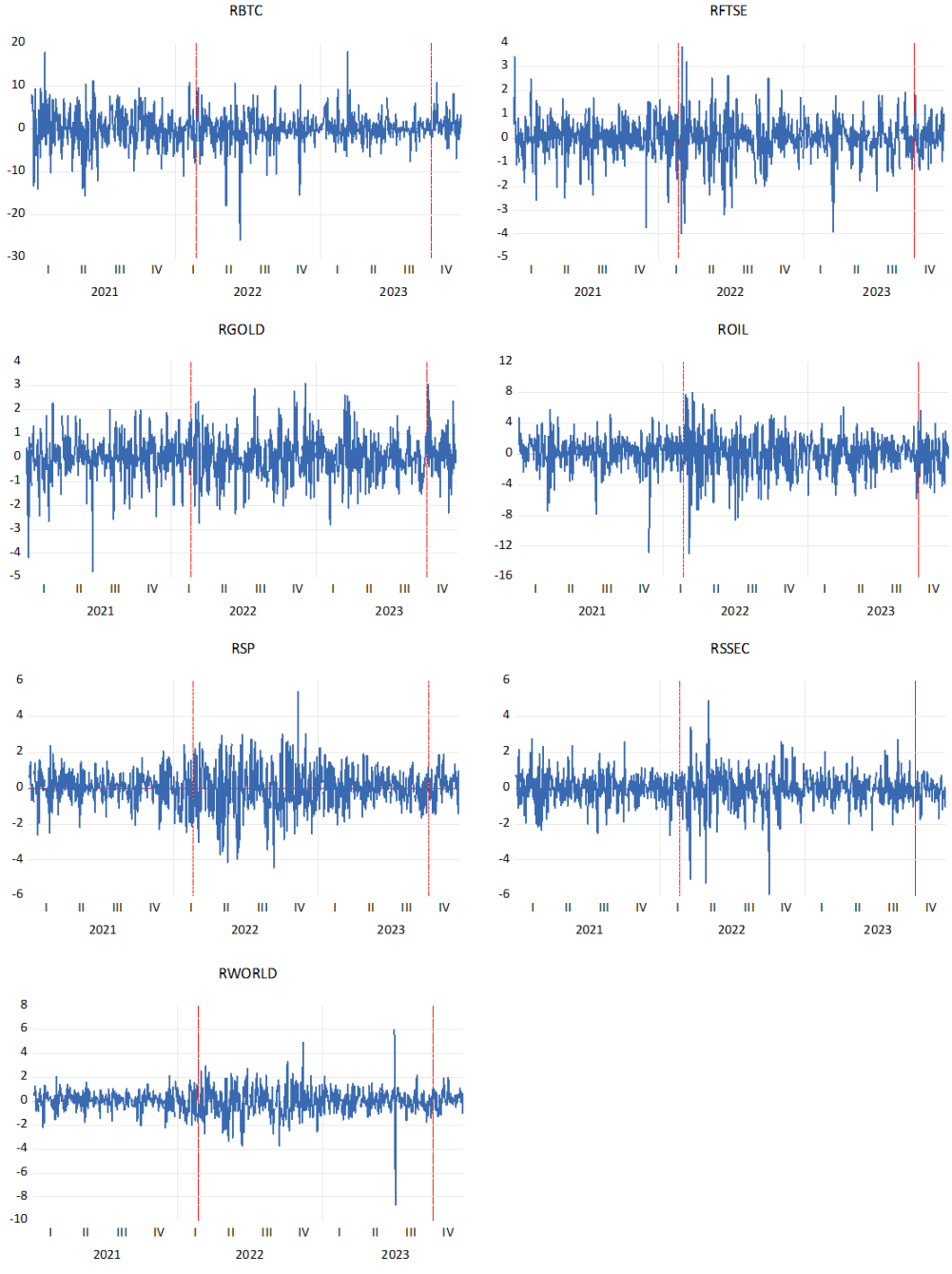


Table 2. *TVP-VAR Model Results for the Whole Sample Period; Pre-war; and War-period*

Panel (A)	BTC	FTSE	Gold	Oil	S&P 500	SSEC	World	From
BTC	82.24	1.90	1.22	0.80	13.05	0.20	0.58	17.76
FTSE	1.36	69.11	2.40	2.26	3.05	1.80	20.02	30.89
Gold	2.07	2.11	82.87	1.14	1.49	0.90	9.42	17.13
Oil	2.31	1.16	1.08	89.81	3.90	1.20	0.54	10.19
S&P 500	12.82	1.84	1.11	3.46	78.98	0.77	1.02	21.02
SSEC	1.43	2.86	1.49	0.50	1.68	87.34	4.70	12.66
World	2.00	16.89	7.21	1.36	8.35	2.00	62.20	37.80
To	21.99	26.75	14.52	9.53	31.53	6.87	36.28	147.47
Inc. Own	104.23	95.86	97.38	99.33	110.51	94.21	98.48	TCI
Net	4.23	-4.14	-2.62	-0.67	10.51	-5.79	-1.52	21.07%
Panel (B)	Pre-War period							
BTC	84.37	3.71	2.27	0.74	8.25	0.19	0.46	15.63
FTSE	2.72	66.74	2.63	2.44	2.70	2.17	20.60	33.26
Gold	4.39	0.44	86.99	1.10	1.00	0.88	5.20	13.01
Oil	3.27	1.35	1.77	85.51	5.82	1.50	0.78	14.49
S&P 500	8.56	2.32	1.64	5.06	80.02	1.28	1.13	19.98
SSEC	2.73	2.45	2.95	0.58	2.49	82.90	5.90	17.10
World	2.86	17.60	4.90	0.89	8.07	3.61	62.08	37.92
To	24.52	27.87	16.16	10.80	28.33	9.64	34.06	151.39
Inc. Own	108.89	94.60	103.16	96.32	108.35	92.54	96.14	TCI
Net	8.89	-5.40	3.16	-3.68	8.35	-7.46	-3.86	21.63%
Panel (C)	War Period							
BTC	78.56	0.35	0.36	0.56	17.60	0.17	2.41	21.44
FTSE	0.91	67.84	2.98	1.97	4.44	1.86	20.00	32.16
Gold	0.93	4.85	77.17	1.31	1.83	0.79	13.13	22.83
Oil	2.96	0.66	1.22	90.87	3.29	0.72	0.29	9.13
S&P 500	17.05	1.48	0.74	1.85	76.11	0.68	2.10	23.89
SSEC	0.41	3.62	0.48	0.41	1.56	91.39	2.12	8.61
World	2.34	16.25	9.29	2.58	11.26	1.03	57.26	42.74
To	24.60	27.19	15.06	8.68	39.97	5.24	40.06	160.80
Inc. Own	103.15	95.03	92.23	99.55	116.08	96.63	97.32	TCI
Net	3.15	-4.97	-7.77	-0.45	16.08	-3.37	-2.68	22.97%

Note. The table reports results for the entire sample period (Panel A), Pre-war (Panel B) and war period (Panel C).

Table 2 illustrates the volatility relationships as identified by the TVP-VAR model across three distinct periods: the entire sample span from January 2021 to December 2023 (Panel A), the pre-war phase spanning January 2021 to February 2022 (Panel B), and the war period extending from February 2022 to December 2023 (Panel C). Upon visual examination of the top panel, it becomes apparent that the overall interconnectedness for the entire sample duration

amounts to 21.07%. This figure implies that 21.07% of the aggregate variation in forecast errors across the sample markets stems from volatility shocks affecting the two commodities and four global equity markets in addition to crypto market under consideration. These outcomes suggest a noteworthy degree of risk transmission among the markets due to their interdependencies. Notably, the MSCI World Index and the S&P 500 markets emerge as pivotal players in this interconnectedness, contributing substantially with proportions of 36.28% and 31.53%, respectively. The UK market closely follows these two equity markets, exhibiting consistent behavior across the three sub-periods. Throughout the entire sample duration and its sub-periods, these three equity markets consistently act as net transmitters of volatility to other markets, underscoring their pivotal roles in shock propagation and lending credence to the idea of the U.S. market's dominant influence on global markets. Moreover, these findings suggest a transfer of volatility shocks from equity markets to commodities markets during geopolitical crises. These findings corroborate with (Yousfi et al., 2024) who found that commodities were less affected by the crises as compared to the equity markets. In addition, (Ali et al., 2024) found that BRICS equity markets were net transmitters of volatility while renewable energy tokens were found to be the net receivers. However, these findings diverge from those of (Mensi et al., 2021), who contended that during the COVID-19 pandemic, spillovers intensified from commodities to equity markets.

Conversely, the Chinese market and the oil markets exhibit the lowest contribution to shocks transmitted to other markets, closely followed by the gold market. The Chinese market accounts for a mere 6.87%, while the oil market contributes 9.53% to the volatility transmissions of other markets. However, volatility spillover returns from the Chinese and oil markets represent a significant portion of their own volatilities, amounting to 87.34% and 89.81% respectively. These findings align with those of (Rawat & Arif, 2018), who observed that the Indian and Chinese markets demonstrated the highest resilience to geopolitical risk among the BRIC nations over the examined period from 1985 to 2017[7]. More recently, (Khan, 2024) found weaker association of the Chinese market with other markets including the U.S., Indian and Pakistani equity markets along with oil and gold. These findings suggest that during the recent geopolitical crisis episodes, the Chinese equity market, along with the oil and gold markets, may present alternative avenues for investment, given their less pronounced correlation with global equity markets, especially the U.S. market. The findings corroborate with (Setiawan et al., 2022) who argued that gold offered a protection against market volatility and geopolitical uncertainty due to the stability and low risk nature of gold. In general, bitcoin was not a good hedge against the geopolitical crisis due to the fact that bitcoin was risk transmitter although less pronounced as compared to the global equity markets. This might be due to the fact that crypto assets

7) The researchers' findings suggest that China and India could offer investors a safe haven during periods of market volatility, indicating their potential as stable and secure investment options amid economic uncertainty.

exhibit high level of safe-haven properties for the foreign exchange currencies as compared to commodities and equity markets (Shahzad et al., 2020).

The outcomes for the respective time segments shed light on volatility interconnections both preceding and during the period of conflict, notably arising from the tensions between Russia-Ukraine and Israel-Palestine. As depicted in Panels (B) and (C), market interlinkages remained relatively subdued prior to the onset of the war crisis, registering at 21.63%, compared to 22.97% during the conflict. Notably, developed equity markets such as the MSCI World, the U.S., and the UK markets made substantial contributions to volatility interconnections, comprising 40.06%, 39.97%, and 27.19%, respectively. This observation suggests that due to their pivotal roles in the global financial landscape, these markets acted as net transmitters of shocks within the system, in line with the findings of (Zeng et al., 2023), who identified more pronounced risk transmissions emanating from the U.S. market to others.

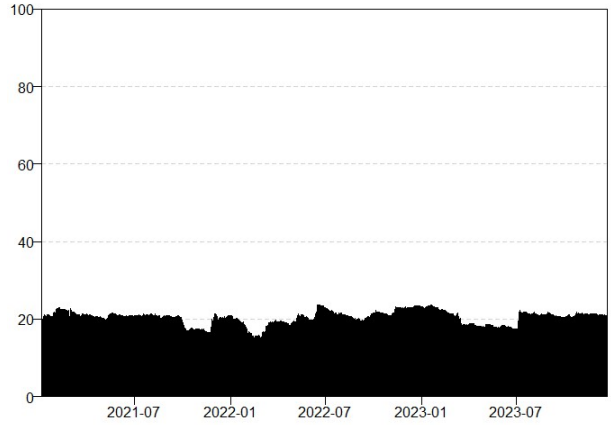
During the war period, gold, oil, and Chinese markets exhibited the lowest contributions to shocks transmitted to other markets. These results find support in the works of (Khan, 2024; Mensi et al., 2021; Pinho & Maldonado, 2022), indicating that gold, oil, and Chinese markets displayed greater independence during recent health crises such as the COVID-19 pandemic. Such findings suggest that these assets could potentially serve as effective hedging instruments against crisis-induced risks.

Figure 2 illustrates the Total Connectivity Index (TCI) for the markets throughout the entire sample duration, as well as during the two specified sub-periods. The TCI indicates a notable escalation during the war period compared to the pre-war phase. Upon visual examination of the figure, it becomes apparent that the most pronounced peaks in volatility coincide with the duration of the Russia-Ukraine conflict. These results contrast with those of (Cui & Maghyereh, 2024), who observed a more pronounced impact of the Israel-Palestine war compared to the aftermath of the Russia-Ukraine conflict. The indication that market volatility intensified more significantly during the Russia-Ukraine conflict than during the Israel-Palestine conflict may be attributed to the substantial global economic influence exerted by Russia and Ukraine.

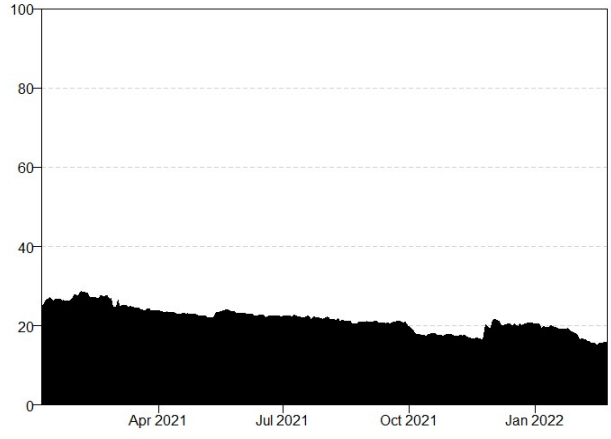
Volatility during the Russia-Ukraine crisis peaked at 22.97% during the war period, marking the highest level observed throughout the investigated time span. Volatility remained elevated during the initial stages of the crisis, gradually tapering off in the ensuing days. In late 2023, discernible shocks emerged in the TCI, likely stemming from the onset of a new conflict between Israel and Palestine on October 7, 2023. However, in contrast to the period surrounding the Russia-Ukraine conflict, the shocks during the Israel-Palestine conflict exhibit a lower magnitude.

Figure 2. The total connectedness index (TCI) for the entire sample period and the two sub-periods

(a) Total Connectedness Index (TCI) for the Whole Sample Period



(b) Total Connectedness Index (TCI) for the Pre-war Period



(c) Total Connectedness Index (TCI) for the war Period

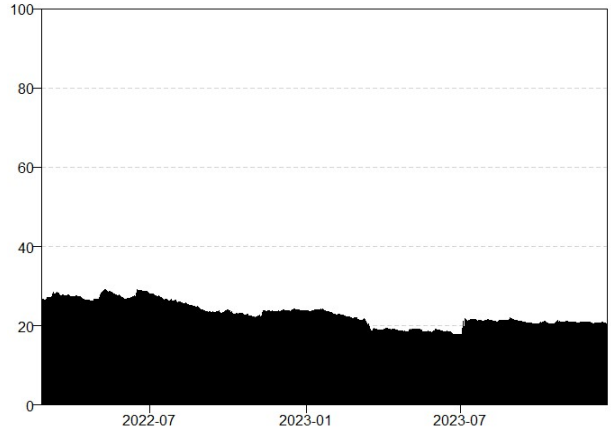


Figure 3. Conditional standard deviation based on EGARCH model

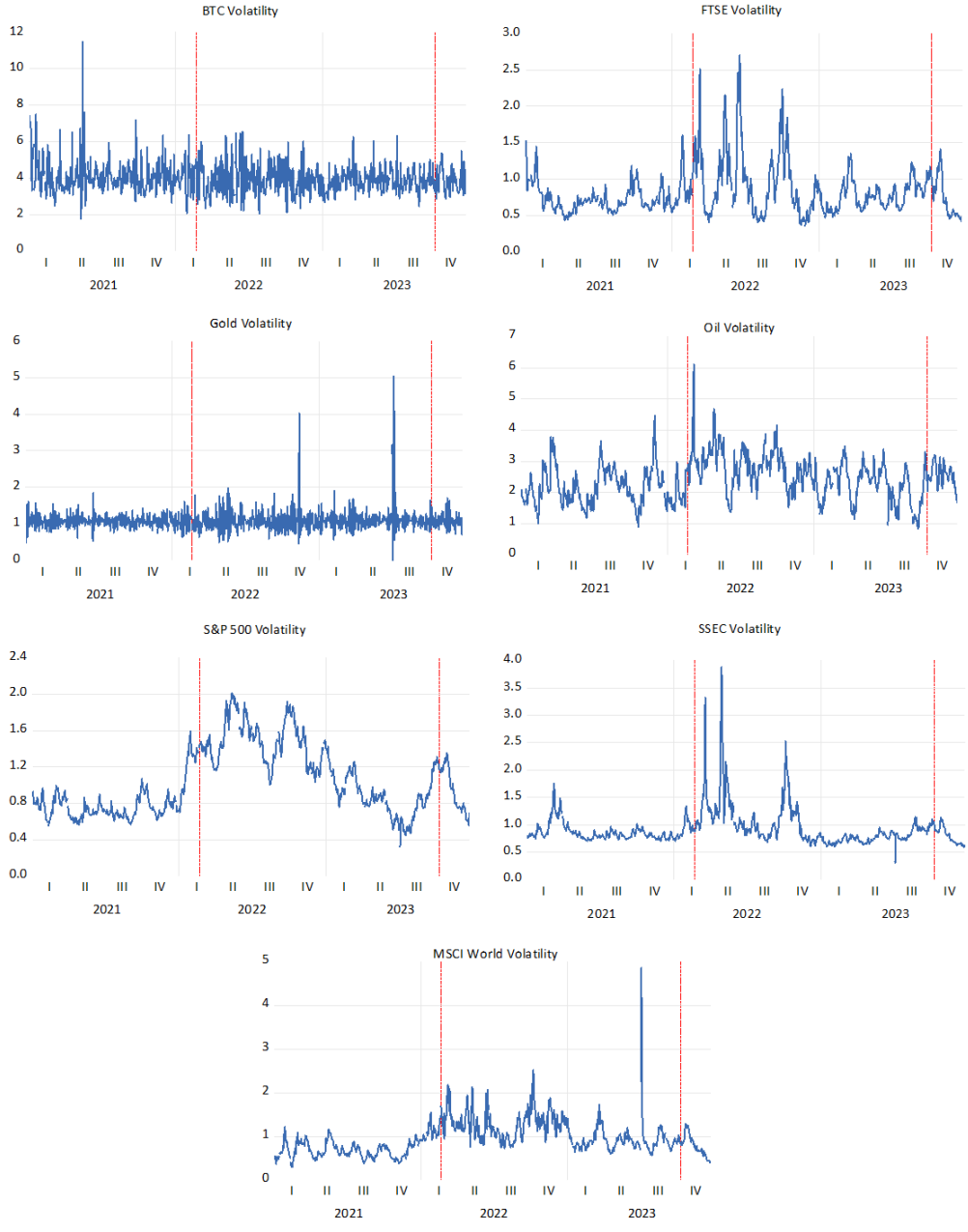


Figure 3 highlights the dynamic trends of estimated conditional volatility, measured through conditional standard deviations, across the markets. The calculation of conditional volatility involves the utilization of the asymmetric EGARCH (1, 1) model. A dotted line delineates

the periods corresponding to the Russian invasion in Ukraine on February 24, 2022, and the Israel-Palestine conflict on October 7, 2023.

The peaks in estimated volatility (as depicted in Figure 3) illustrate that during the Russian-Ukraine conflict, the U.S. market witnessed its highest volatility peak in February 2022, with notable peaks also evident in March 2022. As anticipated, the U.S., UK, and global markets exhibited the most elevated levels of volatility, whereas the Chinese stock market and commodities markets demonstrated comparatively lower levels of conditional volatility. These findings corroborate the outcomes of the TVP-VAR model discussed in the previous section. Furthermore, these observations are consistent with prior research, such as that conducted by (Basuony et al., 2022), which identified increased volatility in the U.S. market and comparatively lower volatility in the Chinese market during pandemics.

The escalation of geopolitical tensions resulting from the Israel-Palestine conflict contributed to adverse market sentiment in the U.S., exacerbating market volatility. In contrast, the Chinese stock markets appeared less impacted during the war period, possibly due to swift government interventions during the COVID-19 pandemic, which conveyed positive signals to investors and alleviated market uncertainty. The EGARCH (1, 1) model indicates that the excessive increase in conditional volatility diminishes across all markets during the war period as these markets absorb the shocks, leading to a decline in conditional volatility.

In summary, these findings corroborate the TVP-VAR model's results, indicating that volatility spillovers were more pronounced during the war period (TCI 22.97%) compared to the pre-war period (TCI 21.63%). These findings hold significant implications for investors and fund managers. To navigate crises such as those experienced during the war period, they should consider adjusting their investment strategies by incorporating assets like oil and gold. Moreover, when contrasted with developed markets such as the U.S. and UK, the emerging market of China offered greater diversification benefits during geopolitical crises. Both the Chinese market and commodities market present promising opportunities for hedging and serving as safe havens against market instability. Amid crisis periods, both equity markets and the crypto market proved unable to safeguard investors' wealth, primarily due to their heightened risk transmissions during turbulent episodes.

V. Conclusion

The objective of this study is to investigate the interrelations between the equity markets of the U.S., UK, China, and the MSCI world indices, alongside significant commodities such as oil and gold, as well as the cryptocurrency market, throughout two recent periods of conflict: the Russia-Ukraine war and the Israel-Palestine conflict. The study's findings indicate that these

crises heightened overall volatility connections among the markets, with risk transmissions being more pronounced during the war periods compared to the pre-war sub-period. Moreover, results from the novel TVP-VAR model reveal that developed markets served as primary risk spreaders in the system, particularly in comparison to the emerging market of China. In particular, the MSCI world and U.S. markets were identified as primary channels for transmitting volatility across the entire sample period, including during the periods of conflict. Moreover, the influence of the Russia-Ukraine war was observed to be more substantial compared to that of the Israel-Palestine conflict, potentially attributed to the greater economic impact by the former two countries. During the war periods, the cryptocurrency market exhibited increased linkages with other markets, thereby spreading volatility across them, suggesting reduced diversification benefits from including cryptocurrencies in portfolios during crisis periods. Furthermore, gold, oil, and the Chinese market demonstrated resilience to geopolitical crises. These findings carry practical implications for investors, fund managers, and policymakers. Investors can manage risks by integrating commodities into their equity portfolios, while policymakers, in turn, may need to adjust their strategies to remain flexible and responsive to evolving market dynamics, especially during times of increased risk. Such measures can enhance market resilience to shocks and ensure continued effective operation even amid turbulent periods.

The current study has certain limitation, including only a limited number of markets in the investigation. Additionally, geopolitical risk index (GPR) may be included as a variable in the system to see its impact on various markets. Future research may expand the number of markets to various regions to show the impact of war crisis on various geographical regions. Future studies could utilize advanced methodologies such as wavelength coherence and quantile-based return frequency linkage measures. In addition, TVP-VAR model with stochastic volatility (TVP-VAR-SV) may be employed for future research that might provide a more integrated analysis of volatility dynamics. These refined approaches have the potential to offer deeper insights into tail risk and the interconnected structure across both time and frequency domains.

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