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From Russia with Volatility: War-induced Spillovers to CEE Stock Markets

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Rusya'dan Volatiliteyle: Savaş Kaynaklı Yayılımların CEE Hisse Senedi Piyasalarına Etkisi

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Abstract

This study investigates the volatility spillover dynamics between the Russian stock market and selected Central and Eastern European (CEE) markets in the context of the Russia-Ukraine war. The directional volatility transmissions from the IMOEX index, representing Russia, to the stock markets of Poland (WIG20), Czechia (PX), Hungary (BUX), Romania (BET), and Croatia (CROBEX) have been analyzed using daily closing price data obtained from Investing.com over the pre-war (February 24, 2016-February 24, 2019) and post-war (February 24, 2022-February 24, 2025) periods by employing the bivariate Full BEKK-GARCH model. By explicitly distinguishing between short-run shock effects and long-run volatility persistence, the study provides evidence on how geopolitical conflicts reshape regional risk transmission structures. The findings reveal a marked increase in volatility interactions following the outbreak of the war, particularly showing significant negative volatility spillovers from Russia to most CEE markets, indicating decoupling and defensive market behavior. As a robustness check, residual-based Granger causality tests derived from diagonal BEKK models support the core findings. The results demonstrate that geopolitical conflicts lead to structural changes in regional market linkages and highlight the need for stronger portfolio diversification strategies by investors and enhanced cross-border financial risk monitoring by policymakers during periods of war.

Keywords: *Volatility spillovers, BEKK-GARCH, Geopolitical risk, Russia-Ukraine war.*

Makale Bilgileri

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Öz

Bu çalışma, Rusya-Ukrayna savaşı bağlamında Rus hisse senedi piyasası ile seçilmiş Orta ve Doğu Avrupa (CEE) piyasaları arasındaki volatilite yayılım dinamiklerini incelemektedir. IMOEX endeksiyle temsil edilen Rusya'dan Polonya (WIG20), Çekya (PX), Macaristan (BUX), Romanya (BET) ve Hırvatistan (CROBEX) hisse senedi piyasalarına yönelik volatilite aktarımları, Investing.com'dan elde edilen günlük kapanış verileri kullanılarak savaş öncesi (24 Şubat 2016-24 Şubat 2019) ve savaş sonrası (24 Şubat 2022-24 Şubat 2025) dönemler için ikili Full BEKK-GARCH modeli kullanılarak analiz edilmiştir. Çalışma, kısa dönem şok etkileri ile uzun dönem volatilite sürekliliğini ayrıştırarak, jeopolitik çatışmaların bölgesel risk aktarım yapısını nasıl dönüştürdüğünü ortaya koymaktadır. Bulgular, savaşın başlamasını takiben volatilite etkileşimlerinde belirgin bir artış olduğunu ve özellikle Rusya'dan çoğu CEE piyasasına doğru anlamlı negatif volatilite yayılımlarının ortaya çıktığını, bunun da ayrışma ve savunmacı piyasa davranışına işaret ettiğini göstermektedir. Sağlamlık kontrolü olarak, diagonal BEKK modellerinden türetilen artık tabanlı Granger nedensellik testleri temel bulguları desteklemektedir. Sonuçlar, jeopolitik çatışmaların bölgesel piyasa bağlantılarında yapısal dönüşümlere yol açtığını ve savaş dönemlerinde yatırımcılar açısından daha güçlü portföy çeşitlendirme stratejilerine, politika yapıcılar açısından ise sınır ötesi finansal risklerin daha etkin izlenmesine ihtiyaç duyulduğunu göstermektedir.

Anahtar Kelimeler: *Volatilite yayılımları, BEKK-GARCH, Jeopolitik risk, Rusya-Ukrayna savaşı.*

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1. Introduction

Since the dissolution of the USSR, various geopolitical tensions across the post-Soviet space have persisted to the present day. The 2008 Georgia crisis and the 2014 Crimea crisis were among the events where these tensions escalated. Russia's annexation of Crimea in 2014 and the outbreak of conflict in the Donbas region that same year marked Ukraine as one of the central arenas where these tensions came to the surface. From the time it declared independence, Ukraine aligned itself more closely with the West than with Russia, and consequently became a central target of nationalist currents within Russia. Ukraine, functioning as a buffer zone between NATO, which had been pursuing eastward enlargement since 1997, and Russia, experienced internal unrest that was further exacerbated by Russia's aggressive interventions. Russia appeared to prefer the presence of at least an unstable adversary in this region rather than a stable pro-Western government (Malyarenko & Wolff, 2018). However, pro-Western alignments in Ukraine, particularly with the growing prospect of NATO and EU membership, provoked even harsher reactions from Russia, which sought to reassert its hegemony over the post-Soviet territories and restore its global power status (Samokhvalov, 2015). In February 2022, Russia launched its invasion of Ukraine in a move that was relatively unexpected. Unlike the relatively muted reactions to the annexation of Crimea in 2014, this action elicited a far stronger response from the West. From that point forward, Ukraine received large-scale military and economic assistance, while Russia faced severe economic, political, and cultural sanctions. This process ultimately resulted in Russia's significant isolation from the global order.

This war, in addition to its geopolitical implications, has had significant repercussions on global economic balances, most notably through the restructuring of global trade and energy markets (Steinbach, 2023; Sun et al., 2024). Disruptions in global trade networks and supply chains have led to price increases in various commodities and have contributed to rising inflation (Cui et al., 2023; Hamza et al., 2024; Maurya et al., 2023). The sharp increases in agricultural commodity prices (Devadoss & Ridley, 2024; Fang & Shao, 2022) and energy prices (Aizenman et al., 2024; Liu & Lee, 2025; Tong, 2024) have threatened energy security in the Eurozone (Henderson, 2024; Luschini et al., 2024; Zhou et al., 2023) and heightened concerns regarding global food security (Behnassi & El Haiba, 2022; Rabbi et al., 2023; Saccone & Vallino, 2025; Urak et al., 2024).

The gradual escalation of tensions in the region over the years and the subsequent outbreak of war placed the global economy under a new strain at a time when it had not yet fully recovered from the repercussions of COVID-19. Europe, in particular, was severely affected due to its geographical position and its dependence on energy and food supplies (Liadze et al., 2023). Such economic disruptions have also contributed to a decline in global GDP (Khudaykulova et al., 2022; Mbah & Wasum, 2022).

On the other hand, one of the most significant adverse consequences of the war shock and the ongoing regional tensions has been observed in financial markets. The purpose of this study is to examine whether the Russia-Ukraine war has had any impact on the risk transmission mechanisms among stock markets in the region and, if so, to analyze the characteristics of such an impact. In this regard, volatility transmissions from Russia, which still maintains a hegemonic position in the region, to the stock markets of Central and Eastern European (CEE) countries are investigated. Russia sustains its regional hegemony through energy policies, trade relations, and support for various extremist political parties (Orenstein, 2019). With the intensification of tensions in the Ukrainian region over the years, these efforts have also increased in scope and magnitude. CEE countries, particularly given their dependence on energy, may exhibit a fragile structure in the face of economic shocks originating from Russia (Ostrowski, 2022; Velchev, 2024). Indeed, in the post-war period, it is to be expected that they would be relatively more affected by the economic sanctions imposed on Russia compared to other European countries (Kulikova & Sinitsina, 2022). In this context, in order to more clearly observe how the war period transformed the risk linkages among financial markets, the study was conducted over two sub-periods: a relatively stable pre-war period and the hot war period beginning with the invasion of Ukraine.

Research on the impact of the war on financial market linkages and risk transmission dynamics remains quite limited. In the limited number of studies examining the impact of the Russia-Ukraine war on risk transmission mechanisms in financial markets (Qureshi et al., 2022; Sio-Chong U et al., 2024; Wu et al., 2023), transmission to regional CEE stock markets has generally been addressed indirectly; intra-regional risk spillover dynamics have not been directly analyzed. This study fills an important gap in the literature and enhances the study's originality by focusing on CEE markets that have strong historical, economic, and geopolitical ties with Russia and directly examining the regional risk transmission structure caused by war-induced shocks. Moreover, the fact that regional problems have yet to be resolved renders the subject highly topical and further enhances the value of the study. Clearly identifying these dynamics will facilitate the adoption of differentiated policy actions at the regional level and provide data that can generate foresight for both institutional and individual investors operating in the relevant markets. Perhaps even more importantly, despite the relatively lesser importance of financial issues compared to human life, bringing greater visibility to the economic consequences of war may foster broader sympathy among individuals for more peaceful policies in response to geopolitical conflicts.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data and econometric methodology. Section 4 presents the empirical findings and robustness analysis. Section 5 discusses the policy and portfolio implications of the results. Finally, Section 6 concludes the study.

2. Literature Review

In the literature, a considerable number of studies have examined the effects of wars on financial markets and on the interdependence among these markets (Al Refai, 2011; Brune et al., 2015; Burdekin & Siklos, 2022; Fernandez, 2007; Hudson & Urquhart, 2015). Although the economic impacts of the Russia-Ukraine war have been primarily investigated in the context of energy supply, global trade and supply chains, inflation in agricultural commodities, and economic growth rates, studies focusing on the dynamics among financial markets remain relatively limited.

Studies examining the effects of war on financial markets have generally reported negative outcomes and have found that these effects display heterogeneity depending on the characteristics of countries or firms.

Boungou and Yatié (2022), in their pioneering work, identified the negative effects of the war on stock markets and further showed that these effects were stronger in countries geographically closer to the war and in those that condemned it. Similarly, Kumari et al. (2023) found that the war had a negative impact on stock markets and that the degree of this impact varied according to geographical proximity and market development. In contrast, Boubaker et al. (2022) documented that more globalized markets experienced these negative effects more intensely.

Assaf et al. (2023) investigated the effects of the war on global financial markets using the event study method and detected negative abnormal returns across markets. They also observed regional differences in the magnitude of the negative reaction, with the largest negative returns occurring in the stock exchanges of EMEA countries. Chowdhury and Khan (2024), also employing the event study method, reported mixed results, noting that some markets reacted positively while others reacted negatively to the war. They explained the positive abnormal returns by increased corporate revenues resulting from higher government spending.

Ahmed et al. (2023) analyzed the effects of the war not only at the country level but also across sectors and firms. They found that the financial services sector experienced the strongest negative impact and that smaller firms were disproportionately affected. Abbassi et al. (2023), in a similar vein, examined 531 firms in G7 countries and concluded that stock prices were highly sensitive to geopolitical shocks arising from the war, while also identifying anomalies related to firm size.

Tarigan et al. (2025) investigated the impact of geopolitical risk, commodity prices, and foreign exchange rates on sectoral stock indices in G20 countries during the pre-war and wartime periods. Their empirical findings indicated that foreign exchange rates affected all sectors, whereas geopolitical risk and commodity prices had significant effects on the energy and transportation sectors. Rossi et al. (2025) measured the responses of company stocks classified by energy dependency across three sub-periods: pre-war, the onset of war, and the subsequent period. They found that brown stocks outperformed green stocks prior to the war, but with the onset of conflict, brown stocks suffered both return losses and heightened volatility. However, in the later period, as alternative energy sources from different countries became available, the performance of brown stocks once again surpassed that of green stocks.

A limited number of studies examining the effects of the war in the context of risks and volatility spillovers in financial markets have generally reported increased risk levels and heightened volatility spillovers.

Qureshi et al. (2022) demonstrated that post-war sanctions on Russia not only increased systemic risk in the Russian market but also raised systemic risks in European and U.S. markets to varying degrees, while identifying China as the only market that remained relatively vulnerable. Wu et al. (2023), analyzing eight developed stock markets, showed that market volatility increased with the onset of the war and that NATO countries acted as risk transmitters, while non-NATO countries assumed the role of risk recipients. Sio-Chong U et al. (2024) further noted a significant rise in volatility spillovers among different financial markets following the Russia-Ukraine war.

3. Data and Econometric Methodology

The principal variables of the study consist of Russia and the CEE countries. With the onset of the Russia-Ukraine war, the analysis focuses on the volatility spillover dynamics from the Russian stock market to the stock markets of the CEE region, as well as on how these dynamics have been altered by the war. To identify the volatility transmission dynamics, the bivariate (full) BEKK-GARCH method is employed. Furthermore, robustness checks are conducted by estimating VAR models based on the residuals obtained from the diagonal BEKK-GARCH models.

3.1. Data

The study investigates how the Russia-Ukraine war has influenced and transformed the risk transmission from the Russian stock market to the stock exchanges of CEE countries. The benchmark indices of the respective countries are employed for the analysis. Specifically, the CEE markets included are Poland (WIG20), the Czech Republic (PX), Hungary (BUX), Romania (BET), and Croatia (CROBEX). Daily closing prices of the indices are used, and their logarithmic returns are computed and incorporated into the analysis. The logarithmic return series were computed as $ln(P_t / P_{t-1})$ and used in their original form without scaling. The data are obtained from Investing.com.

Two distinct periods are considered for the analysis: pre-war and post-war. The post-war period spans from February 24, 2022 (the date when large-scale military offensives commenced) until February 24, 2025. The pre-period, in turn, covers February 24, 2016 to February 24, 2019. This pre-war window was selected to exclude the effects of COVID-19 and to ensure a relatively stable benchmark period. In addition, the pre-war period was selected to ensure temporal proximity and comparability with the post-war period, thereby reducing the potential influence of structural changes in market dynamics over longer horizons. Selecting a more recent benchmark helps to minimize biases arising from time-varying volatility structures and regime shifts, allowing for a more consistent comparison of volatility transmission mechanisms. While alternative pre-war windows could be considered, the selected period provides a stable and comparable baseline for isolating the effects associated with the war. Nevertheless, the exclusion of the COVID-19 period constitutes a limitation of the study, as structural changes occurring during the omitted interval may also have influenced the dynamics of regional financial markets. Future research may jointly examine the pandemic and war periods within a unified analytical framework to disentangle their respective effects.

Only those trading days on which all markets were jointly open are included in the dataset (To ensure consistency across markets, only overlapping trading days were retained, and non-synchronous holidays were aligned by excluding days with missing observations. No interpolation was applied, and the final dataset consists solely of synchronized observations across all indices). Descriptive statistics of the variables employed in the study are presented in Table 1.

Table 1. Descriptive Statistics and ARCH-LM Test Results

Variables	Min.	Max.	Mean	Median	Std. Dev.	D.S. Risk	PP	ADF	Obs.
				Pre-Period					
IMOEX	-0.0823	0.0383	0.0004	0.0005	0.0096	0.0069	-25.740*	-10.634*	680
WIG20	-0.0825	0.0487	0.0003	0.0006	0.0112	0.0076	-27.610*	-27.206*	680
PX	-0.0584	0.0259	0.0002	0.0005	0.0075	0.0061	-24.569*	-8.229*	680
BUX	-0.0450	0.0392	0.0008	0.0011	0.0104	0.0071	-27.459*	-10.359*	680
BET	-0.1189	0.0368	0.0003	0.0006	0.0093	0.0088	-24.001*	-5.897*	680
CROBEX	-0.0311	0.0223	0.0001	0.0002	0.0060	0.0048	-24.014*	-5.491*	680
ARCHLM(1)			IMOEX	WIG20	PX	BUX	BET	CROBEX	
			14.815*	33.967*	19.021*	4.730**	20.046*	101.178*	
				Post-Period					
IMOEX	-0.1905	0.0976	0.0002	0.0011	0.0202	0.0194	-29.417*	-20.898*	662
WIG20	-0.0603	0.1407	0.0004	0.0006	0.0148	0.0092	-25.755*	-8.558*	662
PX	-0.0579	0.0493	0.0005	0.0009	0.0089	0.0076	-24.772*	-16.080*	662
BUX	-0.1024	0.0444	0.0009	0.0014	0.0123	0.0105	-27.601*	-14.692*	662
BET	-0.0477	0.0295	0.0004	0.0010	0.0086	0.0068	-23.143*	-23.209*	662
CROBEX	-0.0659	0.0370	0.0007	0.0006	0.0060	0.0053	-29.106*	-29.626*	662
ARCHLM(1)			IMOEX	WIG20	PX	BUX	BET	CROBEX	
			39.585*	2.559***	3.113***	27.518*	15.355*	345.652*	

Note: D.S. Risk refers to downside risk calculated using only negative daily returns. PP is Philips-Perron unit root test (Phillips & Perron, 1988) and ADF is Augmented Dickey-Fuller unit root test (Dickey & Fuller, 1979). For the PP, the spectral estimation method was selected as Bartlett kernel, and the suitable bandwidth was determined using the NeweyWest method. For the ADF, the Akaike Information Criterion was used to determine the appropriate lag length. The unit root tests were conducted including trend and intercept. The symbols * denote 1%, ** denote 5% and *** denote 10% significance levels.
Source: Own calculation by the author(s).

An examination of Table 1 reveals that, during the pre-period, BUX exhibited the highest average return performance, while CROBEX recorded the lowest. When considering standard deviations, the findings are consistent with the principle of the risk–return trade-off. BUX emerges as the index with the second-highest risk level after WIG20. Conversely, CROBEX registered the lowest risk during this period. The downside risk ratios display a pattern almost identical to that of total risk.

In the post-war period, BUX once again stands out as the index with the highest average return among those analyzed. During this period, CROBEX increased its average return nearly sevenfold. Another noteworthy observation is that IMOEX was the only index to record a decline in average returns in the post-period. Compared to the pre-period, the average return of IMOEX dropped by approximately half. While the risk levels of the other indices remained almost unchanged across the two periods, the total risk of IMOEX nearly doubled in the post-period. The downside risk of IMOEX paints an even more adverse picture, rising to nearly three times its pre-period level. These shifts in the return and risk profile of IMOEX clearly demonstrate the profound impact of the war on the stock market. On the other hand, the overall change in total risk across CEE markets appears relatively flat, with only minor increases observed between the two periods. However, in terms of downside risk, there were notable increases, except for BET. Taken together with the improvements in return levels, this suggests that, starting from the onset of the war, risk premia in CEE markets increased, and the markets evolved toward a more speculative structure.

The results of the unit root tests indicate that all variables included in the study are stationary at level.

3.2. Econometric Methodology

The full BEKK-GARCH model is a widely employed method for identifying volatility transmission across financial markets. It has proven particularly effective in emerging and frontier markets (Gomes & Chaibi, 2014). The bivariate specification was preferred instead of a single multivariate BEKK model because the primary objective of the study is to examine the pairwise volatility transmission from the Russian stock market to each CEE market individually. Moreover, estimating a full multivariate BEKK model with six markets would substantially increase the number of parameters, reducing estimation efficiency and numerical stability (Caporin & McAleer, 2012). Compared to the diagonal BEKK-GARCH, the full BEKK-GARCH provides a more comprehensive framework; however, the larger number of parameters may occasionally lead to estimation biases (Allen & McAleer, 2018). For this reason, robustness checks were conducted using the diagonal BEKK-GARCH in addition to the full specification. In BEKK-GARCH models, the use of a (1,1) lag order generally yields reliable results in capturing volatility transmissions (Xie et al., 2021). Consistent with this, the Bayesian Information Criterion (BIC) also supported the selected specification. Accordingly, BEKK-GARCH(1,1) models were employed to detect volatility dynamics among financial time series.

$$Q_t = CC' + A\varepsilon_{t-1}\,\varepsilon'_{t-1}A' + BQ_{t-1}B' \tag{1}$$

Equation 1 represents the full BEKK-GARCH(1,1) specification for modeling the conditional variance-covariance matrix Q_t of two financial return series. In this specification Q_t denotes the $n{\times}n$ time-varying conditional variance-covariance matrix of asset returns at time t. The matrix C is an upper (or lower) triangular matrix that guarantees the positive definiteness of Q_t. Matrices A and B are fully parameterized square matrices (i.e., not restricted to diagonal form), enabling the model to capture both own-market and cross-market effects. Specifically, A reflects the short-run effects of past shocks, where each off-diagonal element represents the extent to which innovations in one market affect the conditional variance of another market. Likewise, B captures the persistence of past conditional variances, where the off-diagonal terms allow for transmission of volatility across markets over time. The residual vector ε_{t-1} derived from the mean equation, introduces new information into the conditional variance system.

On the other hand, the results obtained from the full BEKK-GARCH models were subjected to a robustness check through causality tests based on diagonal BEKK-GARCH models. Particularly in high-frequency series, the Diagonal BEKK-GARCH provides the advantage of greater parsimony, offering a more stable structure. From this perspective, some researchers prefer it over the full BEKK-GARCH when examining volatility spillover dynamics (Iuga et al., 2024; Zolfaghari et al., 2020). In the diagonal BEKK-GARCH specification, the A and B matrices take a diagonal form, thereby incorporating only the past shocks of each variable itself. Granger causality tests (Granger, 1969) were applied to the residuals obtained from the diagonal models in order to verify the robustness of the directional shock transmission dynamics identified by the full BEKK-GARCH model.

The conditional mean equation included only a constant term. The full BEKK-GARCH models were estimated under the Gaussian error distribution assumption using the BFGS optimization algorithm in WinRATS. The diagonal BEKK-GARCH models used for robustness checks were estimated in EViews 13.

4. Empirical Results

4.1. Volatility Spillovers

Given the nonlinear matrix structure of the Full BEKK-GARCH model, the off-diagonal elements of the A and B matrices do not represent isolated marginal effects on conditional variances. Rather, they indicate the direction and statistical relevance of cross-market shock and volatility-persistence transmission within the overall variance-covariance system. Therefore, the signs of these coefficients are interpreted cautiously as transmission parameters, not as direct one-to-one measures of positive or negative volatility effects. The empirical interpretation is based on the joint pattern of sign, statistical significance, and pre-/post-war changes in the cross-market coefficients, and is further assessed through the diagonal BEKK-based Granger causality robustness analysis.

Table 2 presents the results of the full BEKK-GARCH model. According to the empirical findings derived from the model, during the stable pre-war period, the volatility transmission structure was generally directed from the CEE countries toward the Russian market. Volatility spillovers from IMOEX were limited to BUX and WIG20. Shocks originating in IMOEX initially produced a short-term hedge effect on BUX; however, in the long run, this relationship evolved into volatility contagion. For WIG20, only a positive GARCH effect was observed, with IMOEX volatility exhibiting long-term spillover into WIG20.

Volatility spillovers from the CEE countries to the Russian stock market were, in general, characterized by a positive ARCH component and a negative GARCH component (with the exception of BET and CROBEX). While immediate shocks in the CEE markets triggered short-term increases in volatility within the Russian stock market, these effects were ultimately absorbed by IMOEX in the long run, leading to inverse pricing dynamics. The transmission from CROBEX to IMOEX diverged from this general pattern, as IMOEX demonstrated decoupling behavior from CROBEX volatility both in the short and long run. In contrast, spillovers originating from BET intensified over time and eventually transformed into contagion.

In the post-war period, however, the volatility transmission dynamics from Russia to the CEE markets underwent significant changes. The ARCH effects from IMOEX to all markets except CROBEX became statistically significant and positive. In the long run, volatility spillovers turned negative for all markets except PX, suggesting that CEE markets served as an effective hedge against IMOEX volatility. By contrast, the risk transmission from IMOEX to PX became substantially stronger and persistent.

On the other hand, the risk spillovers from CEE markets to IMOEX during the wartime period evolved into a more complex structure.

Table 2. Full BEKK-GARCH Results

Variables	$A_{(1,2)}$	$A_{(2,1)}$	$B_{(1,2)}$	$B_{(2,1)}$
IMOEX ↔		*Pre-Period*		
WIG20	0.1679* (0.0413)	0.0021 (0.0335)	-0.2343* (0.0288)	0.1961*(0.0240)
PX	0.0788* (0.0223)	0.0585 (0.0470)	-0.0594* (0.0182)	-0.0114 (0.0209)
BUX	0.1304* (0.0476)	-0.1315* (0.0483)<	-0.1656* (0.0376)	0.1613*(0.0289)
BET	0.0901* (0.0331)	-0.0208 (0.0502)	0.1509* (0.0568)	0.0230 (0.0307)
CROBEX	-0.1206* (0.0327)	0.0203 (0.0815)	-0.1757* (0.0577)	-0.1930 (0.1411)
IMOEX ↔		*Post-Period*		
WIG20	0.1555* (0.0244)	0.2074* (0.0476)	0.3539* (0.0199)	-0.6239* (0.0285)
PX	0.0744* (0.0191)	0.3879* (0.0803)	-0.2734* (0.0114)	1.2362* (0.0683)
BUX	-0.0270** (0.0135)	0.0829* (0.0293)	0.3198* (0.0108)	-0.6627* (0.0223)
BET	-0.0618* (0.0162)	0.7577* (0.0710)	0.1649* (0.0122)	-0.5998* (0.0343)
CROBEX	-0.0070 (0.0142)	0.1972 (0.1406)	0.0257 (0.0163)	-0.1845 (0.1443)

Model fit (Log-Likelihood): WIG20 = 4362.33 (3638.85), PX = 4649.42 (3981.55), BUX = 4396.19 (3786.52), BET = 4478.32 (4000.25), CROBEX = 4780.35 (4223.26).

Model fit (BIC): WIG20 = -12.7057 (-10.8659), PX = -13.5501 (-11.9013), BUX = -12.8053 (-11.3118), BET = -13.0469 (-11.9578), CROBEX = -13.9352 (-12.6315).

Note: The table reports the estimated Full BEKK-GARCH coefficients, with standard errors reported in parentheses. Model fit statistics (Log-Likelihood and BIC) are reported below the table. For these statistics, values outside parentheses refer to the pre-war period, whereas values in parentheses refer to the post-war period. The symbols *, ** and *** indicate statistical significance at the 1%, 5% and 10% levels, respectively.
Source: Own calculation by the author(s).

4.2. Robustness Check

Figure 1 presents the conditional correlation patterns between the IMOEX and the stock markets of CEE countries. In the pre-period, the highest correlation with IMOEX is observed for the WIG20, while the lowest is with the CROBEX. Overall, the correlation patterns during the pre-period remain relatively stable; however, at the beginning of the second quarter of 2018, a sharp decline is evident across all graphs. This is likely attributable to the broad sanctions imposed by the United States on Russian oligarchs and companies in April 2018 (see Kuzmarov, 2019 for more details). These sanctions led to a significant contraction in Russia's external financial channels, the closure of several large-scale companies, and sharp declines in the IMOEX. The shock experienced by the Russian economy is considered to have caused a decoupling between the IMOEX and other indices. In the post-period, beginning from the second quarter of 2022, the war shock experienced in the IMOEX once again led to a sharp decline in its correlations with the other indices (with the exception of the BET). In the subsequent period, the conditional correlations fluctuated around the zero axis.

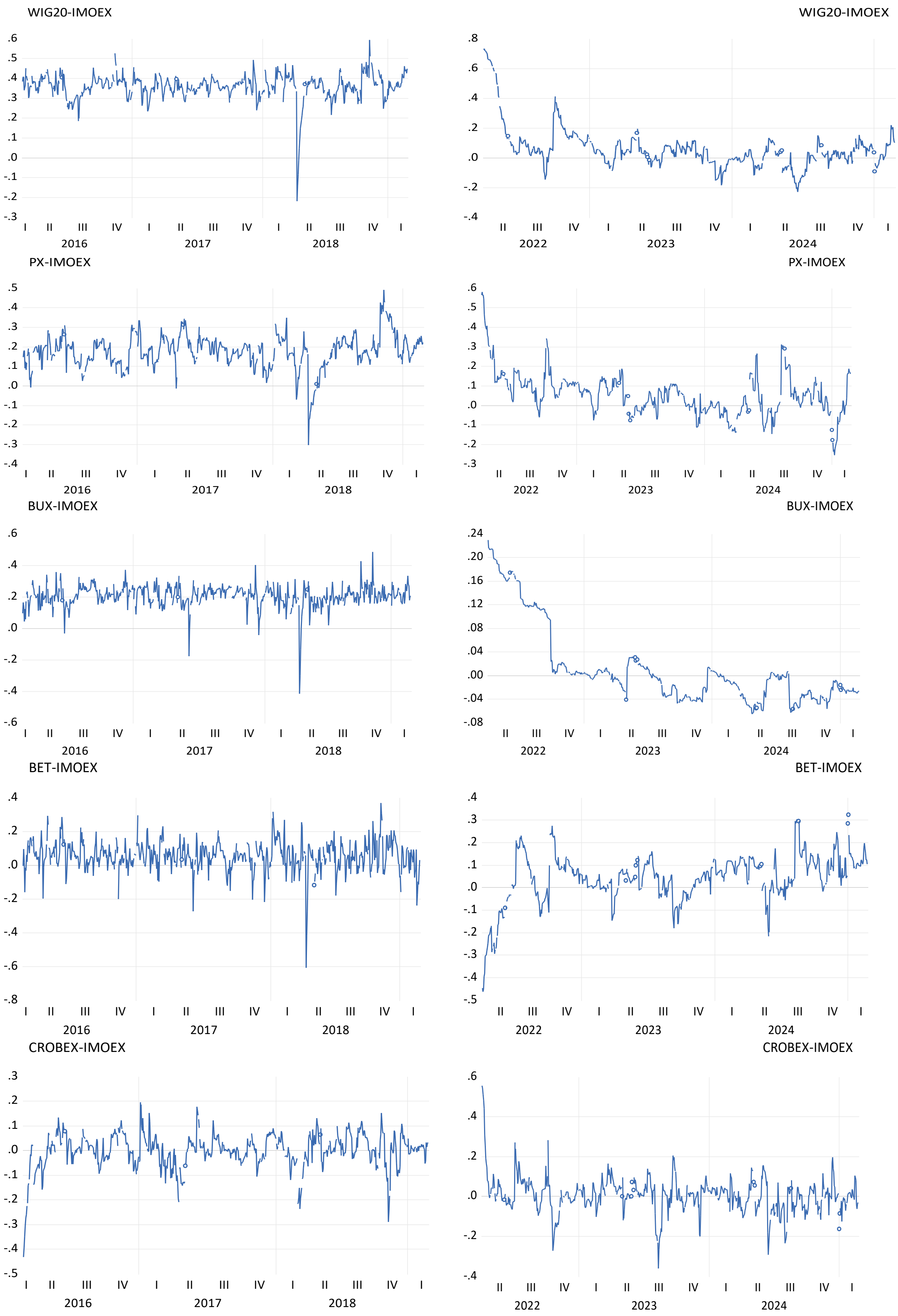

Figure 1. Conditional Correlation Patterns between IMOEX and CEE Markets

The results of the pairwise diagonal BEKK-GARCH models conducted between the IMOEX and the CEE markets are presented in Table 3. According to the model outcomes, both ARCH and GARCH effects are clearly evident across all indices.

Table 3. Diagonal BEKK-GARCH Results

Variables	$A_{(1,1)}$	$A_{(2,2)}$	$B_{(1,1)}$	$B_{(2,2)}$
IMOEX ↔		*Pre-Period*		
WIG20	0.2214* (0.0322)	0.1836*(0.0588)	0.9356* (0.0296)	0.7896* (0.1213)
PX	0.3190* (0.0219)	0.1398* (0.0388)	0.9247* (0.0127)	0.9282* (0.0544)
BUX	0.3269* (0.0393)	0.1696* (0.0504)	0.9073* (0.0241)	0.5304***(0.2720)
BET	0.7936* (0.0261)	0.1356* (0.0453)	0.5414* (0.0425)	0.9313* (0.0660)
CROBEX	0.2959* (0.0301)	0.1374* (0.0365)	0.9142* (0.0152)	0.9115* (0.0773)
IMOEX ↔		*Post-Period*		
WIG20	0.2246* (0.0344)	0.1616* (0.0091)	0.9200* (0.0091)	0.9835* (0.0006)
PX	0.2626* (0.0283)	0.1585* (0.0091)	0.9502* (0.0081)	0.9838* (0.0006)
BUX	-0.0284 (0.0505)	0.1716* (0.0097)	0.9933* (0.0016)	0.9827* (0.0007)
BET	0.2457* (0.0384)	0.1632* (0.0094)	0.9270* (0.0208)	0.9833* (0.0006)
CROBEX	0.3522* (0.0417)	0.1683* (0.0096)	0.7924* (0.0450)	0.9830* (0.0006)
Model fit (Log-Likelihood): WIG20 = 4544.12 (3682.17), PX = 4644.64 (4021.99), BUX = 4468.28 (3860.65), BET = 4013.12 (4013.12), CROBEX = 4311.29 (4311.29).				
Model fit (BIC): WIG20 = -13.3853 (-11.0331), PX = -13.5752 (-12.0613), BUX = -13.0557 (-11.5732), BET = -12.0345 (-12.0345), CROBEX = -12.9367 (-12.9367).				

Note: The table reports the estimated Full BEKK-GARCH coefficients, with standard errors reported in parentheses. Model fit statistics (Log-Likelihood and BIC) are reported below the table. For these statistics, values outside parentheses refer to the pre-war period, whereas values in parentheses refer to the post-war period. The symbols *, ** and *** indicate statistical significance at the 1%, 5% and 10% levels, respectively.
Source: Own calculation by the author(s).

Table 4 presents the results of the pairwise Granger causality tests conducted using the residuals of the diagonal BEKK-GARCH models. The findings are broadly consistent with the outcomes of the full BEKK-GARCH models. In the pre-period, the general spillover dynamics were directed from the CEE markets toward the IMOEX, whereas in the post-period, the transmission shifted from the IMOEX toward the CEE markets.

To assess the adequacy of the estimated models, additional post-estimation diagnostic tests were conducted. Detailed residual diagnostic results for the full BEKK-GARCH and diagonal BEKK-GARCH specifications are reported in Appendix Tables A1 and A2, respectively. The reported Portmanteau Q(12) and ARCH-LM statistics generally confirm the absence of significant residual autocorrelation and remaining ARCH effects, indicating that both model specifications adequately capture the dynamic variance-covariance structure of the return series across the pre-war and post-war periods.

Table 4. Residual-Based Granger Causality

Period	H_0	F stat.	Prob.	Decision
Pre-Period	resIMOEX ≠> resWIG20	1.9238	0.1468	✓
	resWIG20 ≠> resIMOEX	5.4215	0.0046	X
	resIMOEX ≠> resPX	0.4660	0.6276	✓
	resPX ≠> resIMOEX	3.1174	0.0449	X
	resIMOEX ≠> resBUX	2.5344	0.0391	X
	resBUX ≠> resIMOEX	1.4544	0.2144	✓
	resIMOEX ≠> resBET	0.8274	0.4376	✓
	resBET ≠> resIMOEX	3.0495	0.0480	X
	resIMOEX ≠> resCROBEX	1.3250	0.2435	✓
	resCROBEX ≠> resIMOEX	2.5663	0.0182	X
Post-Period	resIMOEX ≠> resWIG20	1.9080	0.0561	X
	resWIG20 ≠> resIMOEX	2.6529	0.0072	X
	resIMOEX ≠> resPX	0.6367	0.5293	✓
	resPX ≠> resIMOEX	1.0886	0.3372	✓
	resIMOEX ≠> resBUX	1.9757	0.0965	X
	resBUX ≠> resIMOEX	0.7340	0.5689	✓
	resIMOEX ≠> resBET	2.4556	0.0445	X
	resBET ≠> resIMOEX	1.1913	0.3133	✓
	resIMOEX ≠> resCROBEX	3.8044	0.0227	X
	resCROBEX ≠> resIMOEX	0.0249	0.9753	✓

Source: Own calculation by the author(s).

5. Policy and Portfolio Implications

In the post-Russia-Ukraine war period, geopolitical risk factors have spread into the economies of many countries through various transmission channels. The increase in risk premia and the transformation of CEE markets into a more speculative structure are among the clear manifestations of this process. Such speculative surges constitute a factor that must be closely monitored by policymakers. In particular, the importance of macroprudential measures has increased in terms of safeguarding market liquidity. Under necessary circumstances, short-term capital controls may be considered as a possible instrument. Moreover, capital market regulators may also need to adopt measures limiting speculative inflows into the markets.

The striking deterioration observed in both returns and risk levels of the IMOEX once again underscores the adverse effects of wars on capital markets. Under these conditions, Russia needs to attach greater importance to the regional capital market alliances in which it participates to mitigate the negative consequences of international capital market isolation. In addition, the tightening of capital controls may serve as a more functional absorption mechanism against such shocks.

Furthermore, significant changes have been observed in the risk transmission mechanisms from the IMOEX to CEE markets during the war period. In general, due to their regional positions, CEE countries maintain direct or indirect trade and economic linkages with Russia, with energy relations being the most prominent. Except for Romania and Croatia, the other countries are comparatively more dependent on Russian energy supplies. This situation further complicates their positioning within the West-Russia nexus.

Compared to the normal period, during the war, the cross-market risk transmission mechanisms shifted predominantly from Russia to CEE countries. A more detailed assessment reveals that, with the exception of Croatia and the Czech Republic, the CEE markets exhibit a similar pattern: positive ARCH and negative GARCH effects. This implies that shocks originating in the Russian market initially increase risk in the other markets, but in the long run, the persistent volatility in the Russian market exerts a dampening effect on volatility in the others. This can be interpreted as the CEE markets becoming effective hedge alternatives against the Russian equity market during the war period. Such dynamics create opportunities for investors holding IMOEX stocks to construct more risk-balanced portfolios.

On the other hand, markets that deviate from this general pattern deserve special attention. In the case of Croatia, there is no evidence of risk transmission from the Russian market in either the normal or the post-war period. This is thought to stem from Croatia's relatively limited trade and economic relations with Russia compared to other CEE countries. Its lower dependence on Russian energy imports and its geopolitical position, being relatively less exposed to regional risks, may also limit its financial connectedness. This positions the Croatian market as an attractive diversification alternative within the portfolios of IMOEX investors.

The Czech Republic constitutes another market diverging from the general pattern. The volatility spillover dynamics from IMOEX reveal both positive ARCH and positive GARCH effects, with the latter being particularly strong. This differentiation is likely related to the concentration of industrial companies within the PX and the high degree of energy dependence. In addition, the banking-intensive structure may further amplify the degree of financial contagion. However, given that other CEE countries also share high levels of energy dependence, additional factors may underlie such a distinction. One possible explanation is that the Czech Republic occupies a relatively more intermediate position along the EU-Russia axis. Some studies conducted on the Czech Republic indicate a clear division of opinion between two opposing poles in the West-Russia nexus (Čeněk et al., 2024). Similarly, Wenzel et al. (2024) examined the degree of penetration of Russian disinformation across Central European countries, finding that while Poland exhibited resilience, Slovakia and the Czech Republic appeared more receptive. Such dynamics may affect investor perceptions of the Czech market and explain why shocks originating from Russia transmit positively. In conclusion, given the persistent and high volatility transmission observed between the PX and the IMOEX, investments in the Czech Republic warrant more cautious risk management strategies.

6. Conclusion

This study has examined the volatility transmission dynamics between Russia and the stock markets of CEE countries and has revealed how these dynamics have evolved in the context of the Russia-Ukraine war. The findings underscore once again the necessity of implementing risk monitoring and portfolio diversification strategies in a dynamic manner, particularly in the face of geopolitical shocks. As global power balances are being reshaped and geopolitical tensions occur with increasing frequency, understanding how regional conflicts transform market linkages has become essential for developing strategic policy responses and ensuring financial stability. At the same time, dynamically monitoring changes in market connections is of great importance for investors in order to make more rational decisions. This study contributes to such efforts and encourages a deeper investigation into the temporal and structural dimensions of geopolitical financial contagion.

The empirical findings suggest that the Russia-Ukraine war substantially reshaped the pattern of volatility spillovers between the Russian equity market and the selected CEE stock markets. Overall, stronger and more persistent volatility transmission was observed for several market pairs during the post-war period, although the magnitude and direction of these effects varied across countries. Among the sampled markets, the Czech PX index exhibited the strongest and most persistent volatility spillovers from the Russian market, whereas the Croatian CROBEX remained comparatively insulated from cross-market volatility transmission throughout both sub-periods. The estimated BEKK-GARCH models further indicate that volatility persistence remained high across all market pairs, while the residual-based Granger causality analysis confirms that the direction and intensity of volatility spillovers changed following the outbreak of the war. Collectively, these findings support the main hypothesis that the Russia-Ukraine conflict generated a structural change in regional volatility transmission dynamics rather than merely causing a temporary increase in financial uncertainty. The findings of this study are broadly consistent with the growing body of literature suggesting that geopolitical conflicts intensify cross-market volatility transmission and alter regional financial integration patterns (Qureshi et al., 2022; Sio-Chong U et al., 2024; Wu et al., 2023).

From a theoretical perspective, this study contributes to the literature by demonstrating that geopolitical conflicts reshape not only the magnitude but also the persistence and heterogeneity of volatility spillovers across regional equity markets. From a practical perspective, the findings provide useful insights for investors, portfolio managers, and policymakers by highlighting the importance of continuously monitoring evolving market linkages when designing portfolio diversification, risk management, and financial stability strategies under geopolitical uncertainty.

When evaluated in a more general framework, the empirical findings presented in this study show that geopolitical conflicts not only lead to temporary volatility increases but can also create permanent transformations in inter-market risk transmission mechanisms. It is observed that the Russia-Ukraine war has reshaped investor perceptions and portfolio allocation strategies in the region; this situation has led to differentiated responses depending on the structural exposure of CEE markets to geopolitical and economic risks. This finding confirms that under geopolitical stress, financial integration acquires a selective and conditional naturque rather than a homogeneous structure.

In addition, the asymmetric volatility spillover patterns detected in the post-war period indicate that prolonged uncertainty in a dominant market can encourage defensive rebalancing and partial financial decoupling in neighboring markets. Such dynamics reveal the importance of continuously monitoring volatility transmission channels in order to capture the evolutionary nature of regional financial linkages during prolonged conflict periods. In this context, the results obtained emphasize that geopolitical shocks should be treated in empirical financial analyses as structural events rather than temporary fluctuations.

This study is subject to certain limitations. The exclusion of the COVID-19 period and the use of bivariate BEKK-GARCH models may limit the generalizability of the findings. Future research may extend the analysis by employing multivariate volatility models, alternative data sources, and a broader set of financial markets.

Overall, the findings highlight that geopolitical conflicts should be regarded as structural drivers of regional financial integration and volatility transmission, reinforcing the need to incorporate geopolitical risk into both empirical financial research and evidence-based investment and policy decisions.

References

Abbassi, W., Kumari, V., & Pandey, D. K. (2023). What makes firms vulnerable to the Russia–Ukraine crisis?. *The Journal of Risk Finance, 24*(1), 24-39. https://doi.org/10.1108/JRF-05-2022-0108

Ahmed, S., Hasan, M. M., & Kamal, M. R. (2023). Russia–Ukraine crisis: The effects on the European stock market. *European Financial Management, 29*(4), 1078-1118. https://doi.org/10.1111/eufm.12386

Aizenman, J., Lindahl, R., Stenvall, D., & Uddin, G. S. (2024). Geopolitical shocks and commodity market dynamics: New evidence from the Russia-Ukraine conflict. *European Journal of Political Economy, 85*, Article 102574. https://doi.org/10.1016/j.ejpoleco.2024.102574

Al Refai, H. M. (2011). The impact of the Iraq war on the country BETA of MENA markets. *International Journal of Economics and Finance, 3*(2), 12-17. https://doi.org/10.5539/ijef.v3n2p12

Allen, D. E., & McAleer, M. (2018). Theoretical and empirical differences between diagonal and full BEKK for risk management. *Energies, 11*(7), Article 1627. https://doi.org/10.3390/en11071627

Assaf, R., Gupta, D., & Kumar, R. (2023). The price of war: Effect of the Russia-Ukraine war on the global financial market. *The Journal of Economic Asymmetries, 28*, Article e00328. https://doi.org/10.1016/j.jeca.2023.e00328

Behnassi, M., & El Haiba, M. (2022). Implications of the Russia–Ukraine war for global food security. *Nature Human Behaviour, 6*(6), 754-755. https://doi.org/10.1038/s41562-022-01391-x

Boubaker, S., Goodell, J. W., Pandey, D. K., & Kumari, V. (2022). Heterogeneous impacts of wars on global equity markets: Evidence from the invasion of Ukraine. *Finance Research Letters, 48*, Article 102934. https://doi.org/10.1016/j.frl.2022.102934

Boungou, W., & Yatié, A. (2022). The impact of the Ukraine–Russia war on world stock market returns. *Economics Letters, 215*, Article 110516. https://doi.org/10.1016/j.econlet.2022.110516

Brune, A., Hens, T., Rieger, M. O., & Wang, M. (2015). The war puzzle: Contradictory effects of international conflicts on stock markets. *International Review of Economics, 62*(1), 1-21. https://doi.org/10.1007/s12232-014-0215-7

Burdekin, R. C., & Siklos, P. L. (2022). Armageddon and the stock market: US, Canadian and Mexican market responses to the 1962 Cuban missile crisis. *The Quarterly Review of Economics and Finance, 84*, 112-127. https://doi.org/10.1016/j.qref.2022.01.013

Caporin, M., & McAleer, M. (2012). Do we really need both BEKK and DCC? A tale of two multivariate GARCH models. *Journal of Economic Surveys, 26*(4), 736-751. https://doi.org/10.1111/j.1467-6419.2011.00683.x

Čeněk, J., Čejka, M., Đorđević, V., Hrabálek, M., Mlejnková, P., & Mocek, O. (2024). A representative dataset on Czech and Slovak pre-Russia–Ukraine-war attitudes to the West and to the Russian Federation. *Data in Brief, 52*, Article 109871. https://doi.org/10.1016/j.dib.2023.109871

Chowdhury, E. K., & Khan, I. I. (2024). Reactions of global stock markets to the Russia–Ukraine war: An empirical evidence. *Asia-Pacific Financial Markets, 31*(3), 755-778. https://doi.org/10.1007/s10690-023-09429-4

Cui, L., Yue, S., Nghiem, X. H., & Duan, M. (2023). Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. *Resources Policy, 81*, Article 103373. https://doi.org/10.1016/j.resourpol.2023.103373

Devadoss, S., & Ridley, W. (2024). Impacts of the Russian invasion of Ukraine on the global wheat market. *World Development, 173*, Article 106396. https://doi.org/10.1016/j.worlddev.2023.106396

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366a), 427-431. https://doi.org/10.1080/01621459.1979.10482531

Fang, Y., & Shao, Z. (2022). The Russia-Ukraine conflict and volatility risk of commodity markets. *Finance Research Letters, 50*, Article 103264. https://doi.org/10.1016/j.frl.2022.103264

Fernandez, V. (2007). Stock market turmoil: worldwide effects of Middle East conflicts. *Emerging Markets Finance and Trade, 43*(3), 58-102. https://doi.org/10.2753/REE1540-496X430304

Gomes, M., & Chaibi, A. (2014). Volatility spillovers between oil prices and stock returns: A focus on frontier markets. *Journal of Applied Business Research, 30*(2), 509-526. https://hal.science/hal-02314397

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society, 37*(3), 424-438. https://doi.org/10.2307/1912791

Hamza, T., Hamida, H. B. H., Mili, M., & Sami, M. (2024). High inflation during Russia–Ukraine war and financial market interaction: Evidence from C-Vine Copula and SETAR models.

Research in International Business and Finance, 70(Part B), Article 102384. https://doi.org/10.1016/j.ribaf.2024.102384

Henderson, J. (2024). The impact of the Russia-Ukraine war on global gas markets. *Current Sustainable/Renewable Energy Reports, 11*(1), 1-9. https://doi.org/10.1007/s40518-024-00232-x

Hudson, R., & Urquhart, A. (2015). War and stock markets: The effect of World War Two on the British stock market. *International Review of Financial Analysis, 40*, 166-177. https://doi.org/10.1016/j.irfa.2015.05.015

Iuga, I. C., Nerişanu, R. A., & Dragolea, L. L. (2024). Volatility and spillover analysis between cryptocurrencies and financial indices: a diagonal BEKK and DCC GARCH model approach in support of SDGs. *Cogent Economics & Finance, 12*(1), 2437002. https://doi.org/10.1080/23322039.2024.2437002

Khudaykulova, M., Yuanqiong, H., & Khudaykulov, A. (2022). Economic consequences and implications of the Ukraine-Russia war. *International Journal of Management Science and Business Administration, 8*(4), 44-52. https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.84.1005

Kulikova, N., & Sinitsina, I. (2022). Russia–Central and Eastern European Countries: The New Iron Curtain. *Obshchestvo i ekonomika*, (12), 16-39. https://doi.org/10.31857/S020736760023427-8

Kumari, V., Kumar, G., & Pandey, D. K. (2023). Are the European Union stock markets vulnerable to the Russia–Ukraine war?. *Journal of Behavioral and Experimental Finance, 37*, Article 100793. https://doi.org/10.1016/j.jbef.2023.100793

Kuzmarov, J. (2019). "A New Battlefield for the United States": Russia Sanctions and the New Cold War. *Socialism and Democracy, 33*(3), 34-66. https://doi.org/10.1080/08854300.2020.1769383

Liadze, I., Macchiarelli, C., Mortimer-Lee, P., & Sanchez Juanino, P. (2023). Economic costs of the Russia-Ukraine war. *The World Economy, 46*(4), 874-886. https://doi.org/10.1111/twec.13336

Liu, T. Y., & Lee, C. C. (2025). Impacts of the Russia-Ukraine war on energy prices: Evidence from OECD countries. *Policy Studies, 46*(3), 460-492. https://doi.org/10.1080/01442872.2024.2384431

Luschini, A. C., Rego, E. E., & Montebello, N. (2024). How did the Russia–Ukraine war impact energy imports and electricity generation? A comparative analysis between Germany and the United Kingdom. *The Electricity Journal, 37*(3), Article 107396. https://doi.org/10.1016/j.tej.2024.107396

Malyarenko, T., & Wolff, S. (2018). The logic of competitive influence-seeking: Russia, Ukraine, and the conflict in Donbas. *Post-Soviet Affairs, 34*(4), 191-212. https://doi.org/10.1080/1060586X.2018.1425083

Maurya, P. K., Bansal, R., & Mishra, A. K. (2023). Russia–Ukraine conflict and its impact on global inflation: an event study-based approach. *Journal of Economic Studies, 50*(8), 1824-1846. https://doi.org/10.1108/JES-01-2023-0003

Mbah, R. E., & Wasum, D. F. (2022). Russian-Ukraine 2022 War: A review of the economic impact of Russian-Ukraine crisis on the USA, UK, Canada, and Europe. *Advances in Social Sciences Research Journal, 9*(3), 144-153. https://doi.org/10.14738/assrj.93.12005

Orenstein, M. A. (2019). *The lands in between: Russia vs. the West and the new politics of hybrid war.* Oxford University Press. https://doi.org/10.1093/oso/9780190936143.003.0005

Ostrowski, W. (2022). The twenty years' crisis of European energy security: Central and Eastern Europe and the US. *Geopolitics, 27*(3: Decentering the Study of Migration Governance in the Mediterranean), 875-897. https://doi.org/10.1080/14650045.2020.1835863

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335-346. https://doi.org/10.1093/biomet/75.2.335

Qureshi, A., Rizwan, M. S., Ahmad, G., & Ashraf, D. (2022). Russia–Ukraine war and systemic risk: who is taking the heat?. *Finance Research Letters, 48*, Article 103036. https://doi.org/10.1016/j.frl.2022.103036

Rabbi, M. F., Ben Hassen, T., El Bilali, H., Raheem, D., & Raposo, A. (2023). Food security challenges in Europe in the context of the prolonged Russian–Ukrainian conflict. *Sustainability, 15*(6), Article 4745. https://doi.org/10.3390/su15064745

Rossi, F., Ni, Y., Salvi, A., Sun, Y., & Cebula, R. J. (2025). Energy supply shock on European stock markets: evidence from the Russia–Ukraine War. *Journal of Risk and Financial Management, 18*(5), Article 223. https://doi.org/10.3390/jrfm18050223

Saccone, D., & Vallino, E. (2025). Global food security in a turbulent world: Reviewing the impacts of the pandemic, the war and climate change. *Agricultural and Food Economics, 13*(1), Article 47. https://doi.org/10.1186/s40100-025-00388-0

Samokhvalov, V. (2015). Ukraine between Russia and the European Union: triangle revisited. *Europe-Asia Studies, 67*(9), 1371-1393. https://doi.org/10.1080/09668136.2015.1088513

Sio-Chong U, T., Lin, Y., & Wang, Y. (2024). The impact of the Russia–Ukraine war on volatility spillovers. *International Review of Financial Analysis, 93*, Article 103194. https://doi.org/10.1016/j.irfa.2024.103194

Steinbach, S. (2023). The Russia–Ukraine war and global trade reallocations. *Economics Letters, 226*, Article 111075. https://doi.org/10.1016/j.econlet.2023.111075

Sun, M., Cao, X., Liu, X., Cao, T., & Zhu, Q. (2024). The Russia-Ukraine conflict, soaring international energy prices, and implications for global economic policies. *Heliyon, 10*(16), Article e34712. https://www.cell.com/heliyon/fulltext/S2405-8440(24)10743-8

Tarigan, J., Delia, M., & Hatane, S. E. (2025). Impact of the Russia–Ukraine War: evidence from G20 countries. *Studies in Economics and Finance, 42*(1), 135-153. https://doi.org/10.1108/SEF-05-2023-0218

Tong, E. (2024). Repercussions of the Russia–Ukraine war. *International Review of Economics & Finance, 89*(Part A), 366-390. https://doi.org/10.1016/j.iref.2023.07.064

Urak, F., Bilgic, A., Florkowski, W. J., & Bozma, G. (2024). Confluence of COVID-19 and the Russia-Ukraine conflict: Effects on agricultural commodity prices and food security. *Borsa Istanbul Review, 24*(3), 506-519. https://doi.org/10.1016/j.bir.2024.02.008

Velchev, A. (2024). Influence of Central and Eastern European countries on EU's foreign policy. *Foreign Affairs, 34*(5), 59-71. https://doi.org/10.46493/2663-2675.34(5).2024.59

Wenzel, M., Stasiuk-Krajewska, K., Macková, V., & Turková, K. (2024). The penetration of Russian disinformation related to the war in Ukraine: Evidence from Poland, the Czech Republic and Slovakia. *International Political Science Review, 45*(2), 192-208. https://doi.org/10.1177/01925121231205259

Wu, F. L., Zhan, X. D., Zhou, J. Q., & Wang, M. H. (2023). Stock market volatility and Russia–Ukraine conflict. *Finance Research Letters, 55*(Part A), Article 103919. https://doi.org/10.1016/j.frl.2023.103919

Xie, Q., Liu, R., Qian, T., & Li, J. (2021). Linkages between the international crude oil market and the Chinese stock market: A BEKK-GARCH-AFD approach. *Energy Economics, 102*, Article 105484. https://doi.org/10.1016/j.eneco.2021.105484

Zhou, X. Y., Lu, G., Xu, Z., Yan, X., Khu, S. T., Yang, J., & Zhao, J. (2023). Influence of Russia-Ukraine war on the global energy and food security. *Resources, Conservation and Recycling, 188*, Article 106657. https://doi.org/10.1016/j.resconrec.2022.106657

Zolfaghari, M., Ghoddusi, H., & Faghihian, F. (2020). Volatility spillovers for energy prices: A diagonal BEKK approach. *Energy Economics, 92*, Article 104965. https://doi.org/10.1016/j.eneco.2020.104965

Appendix

Table A1. Residual Diagnostic Tests of the Estimated Full BEKK-GARCH Models

Variables	Portmanteau Q(12)	ARCH-LM (Market 1)	ARCH-LM (Market 1)
IMOEX ↔	*Pre-Period*		
WIG20	47.923 (0.476)	0.904 (0.342)	0.774 (0.379)
PX	57.687 (0.080)	1.331 (0.262)	0.176 (0.675)
BUX	56.071 (0.198)	1.324 (0.250)	1.099 (0.294)
BET	48.960 (0.287)	1.611 (0.154)	0.134 (0.713)
CROBEX	50.679 (0.368)	2.635 (0.105)	0.020 (0.886)
IMOEX ↔	*Post-Period*		
WIG20	50.022 (0.393)	1.921 (0.166)	0.862 (0.353)
PX	46.467 (0.535)	0.654 (0.418)	0.577 (0.447)
BUX	46.068 (0.552)	0.008 (0.927)	0.000 (0.986)
BET	50.736 (0.366)	0.546 (0.460)	1.815 (0.107)
CROBEX	52.623 (0.299)	0.979 (0.322)	0.025 (0.873)

Note: This table reports the post-estimation diagnostic test results for the estimated full BEKK-GARCH models. The Portmanteau Q(12) statistic tests the null hypothesis of no residual autocorrelation up to lag 12 based on the standardized residuals. The ARCH-LM statistics evaluate the null hypothesis of no remaining ARCH effects in the standardized residuals of each conditional variance equation. Reported values are test statistics, while the corresponding p-values are presented in parentheses. Values reported under ARCH-LM (Market 1) refer to the MOEX variance equation, whereas ARCH-LM (Market 2) correspond to the partner market variance equation (WIG20, PX, BUX, BET, or CROBEX). Statistics reported above the horizontal divider correspond to the pre-war period, whereas those below correspond to the post-war period.
Source: Own calculation by the author(s).

Table A2. Residual Diagnostic Tests of the Estimated Diagonal BEKK-GARCH Models

Variables	Portmanteau Q(12)	ARCH-LM (Market 1)	ARCH-LM (Market 1)
IMOEX ↔	*Pre-Period*		
WIG20	58.863 (0.135)	0.904 (0.342)	0.774 (0.379)
PX	48.942 (0.156)	0.941 (0.454)	0.176 (0.675)
BUX	54.934 (0.124)	1.324 (0.250)	1.099 (0.295)
BET	53.148 (0.162)	1.871 (0.114)	0.135 (0.714)
CROBEX	46.351 (0.116)	2.635 (0.105)	0.020 (0.887)
IMOEX ↔	*Post-Period*		
WIG20	53.263 (0.279)	1.149 (0.284)	1.219 (0.270)
PX	42.690 (0.690)	1.350 (0.246)	0.212 (0.646)
BUX	60.227 (0.111)	0.010 (0.919)	0.832 (0.362)
BET	56.072 (0.198)	0.481 (0.488)	1.036 (0.309)
CROBEX	59.989 (0.115)	0.003 (0.956)	0.996 (0.319)

Note: This table reports the post-estimation diagnostic test results for the estimated diagonal BEKK-GARCH models. The Portmanteau Q(12) statistic tests the null hypothesis of no residual autocorrelation up to lag 12 based on the standardized residuals. The ARCH-LM statistics evaluate the null hypothesis of no remaining ARCH effects in the standardized residuals of each conditional variance equation. Reported values are test statistics, while the corresponding p-values are presented in parentheses. Values reported under ARCH-LM (Market 1) refer to the MOEX variance equation, whereas ARCH-LM (Market 2) correspond to the partner market variance equation (WIG20, PX, BUX, BET, or CROBEX). Statistics reported above the horizontal divider correspond to the pre-war period, whereas those below correspond to the post-war period.
Source: Own calculation by the author(s).