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The Russia-Ukraine War and Eastern European Stock Markets

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Abstract

We examine the causal relationships and extreme return co-movements between the Russian stock market and adjacent Eastern European (EE) stock markets before and after the recent Russia-Ukraine war. Considering that the EE stock markets are regarded as a group of emerging markets in the same region for the purpose of investment, we are motivated to identify any change in their relationships after the war because this would be critical in terms of stock portfolio diversification. We find that while the war has a positive impact on the causal relationship between the Russian stock market and the Bulgarian stock market, it has a negative impact on the causal relationships between the Russian stock market and the other EE stock markets. Also, extreme return co-movements between the Russian stock market and the Bulgarian stock market are strengthened after the war whereas those between the Russian stock market and the other EE stock markets are weakened after the war. Our study is expected to provide new insight into stock market participants.

***Keywords**: Russia-Ukraine War, Eastern European Stock Markets, Causality, Extreme Return Co-movements, Copula*

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1. Introduction

The recent Russia-Ukraine war has dealt a serious blow to not only adjacent countries' security but also the global economy. Despite harsh economic sanctions imposed by the United States, the EU, and other countries, Russia has continued the war against Ukraine. As, however, Ukraine has made successful counterattacks on the battlefield and balanced the war, the outcome of the war is still uncertain. The outbreak of the Russia-Ukraine war caused an increase in the prices of energy and food products and significantly dented the supply chain around the world. As a result, the conflict between these two countries remained a profound shock to global financial markets.

In this paper, we examine the relationship between the Russian stock market and adjacent Eastern European (EE) countries' stock markets before and after the war. This would be crucial in terms of stock portfolio diversification due to the impact of the Russian stock market crash on adjacent EE countries' stock markets. In other words, when an event triggers the Russian stock market crash, it is important to see how adjacent EE countries' stock markets respond because they are typically regarded as a group of emerging markets in the same region for the purpose of investment. While many studies have focused on the impact of the COVID-19 pandemic on stock markets over the past few years (Baker et al. 2020; Narayan et al. 2020; Phan & Narayan 2020; Baek & Jackman 2021; Harjoto et al. 2021; Herwany et al. 2021; Mazur et al. 2021; Zaremba et al. 2021; Zehri 2021; Gao & Ren 2022; Ramakrishna & Kalpakam 2022), few studies have analyzed the effect of the recent Russia-Ukraine war on EE stock markets.

Traditionally, there have been extensive studies on the relationship between EE stock markets and developed stock markets. While some studies identify the short-run or long-run relationship between developed stock markets and EE stock markets by investigating their cointegration or causality (Yuce & Simga-Mugan 2000; Patev et al. 2006; Syllignakis & Kouretas 2009; Guidi & Ugur 2014), other studies examine return co-movements, risk contagion, and spillover effects between developed stock markets and EE stock markets during market downturns (Chelley-Steeley 2005; Harrison & Moore 2009; Dajcman et al. 2012; Horvath & Petrovski 2013; Barunik & Vacha 2013; Harkmann 2014; Horvath et al. 2017; Joseph et al. 2020).

On the other hand, some studies focus on the relationship between EE stock markets. Jochun et al. (1999) investigate EE stock market indices with a focus on the 1997/98 emerging market crisis and discover a long-run relationship between these markets for the pre-crisis period. Egert and Kocenda (2007) examine return co-movements between three EE stock markets and find no cointegrating link between them. Poshakwale and Murinde (2010) delve into return volatilities in Hungarian and Polish stock markets using daily index returns and show that these two markets have a non-linear relationship with conditional heteroscedasticity. Todea and Plesoianu (2013) show empirical evidence that foreign portfolio investment has a significant impact on EE stock markets' information efficiency without regard to short- or long-run dependence. Reboredo et al. (2015) examine how EE stock markets are dependent using copula functions with different types of tail dependence. They find that all of the markets are positively dependent and that Hungary, the Czech Republic, and Poland are more strongly dependent. However, Ferreira (2018) argues that the dependence levels of Hungary, the Czech Republic, and Poland decrease over time. Tillfani et al. (2020) investigate EE stock market integration and show that the stock markets of Hungary, the Czech Republic, Poland, Romania, and Croatia are more integrated than those of the other EE countries. Milos et al. (2020) examine the multifractal properties of EE stock markets and find that their returns show long-run correlations, and thus, they are not efficient markets. Overall, these studies show that EE stock markets are connected through their return movements or risk transmissions. However, as shown in some studies above, it seems that EE stock markets tend to be grouped according to the degree of their dependence or integration. This grouping is likely to significantly influence portfolio selections from EE stock markets, especially during market downturns. Thus, we are strongly motivated to analyze how EE stock markets react to the Russian stock market crash provoked by the recent Russia-Ukraine war.

We pose two research questions. First, how does the Russia-Ukraine war impact the short-run relationships between the Russian stock market and adjacent EE stock markets? We investigate if there is any change in their short-run relationships by comparing their causal relationships before and after the war. Second, we examine extreme return co-movements and also see if there is any change in their co-movements before and after the war. Again, since EE stock markets are typically classified as a group of emerging markets in the same region for the purpose of investment, it is worth analyzing how EE stock markets respond to the Russian stock market crash in terms of stock portfolio diversification. To the best of our knowledge, since no study has done similar research, we make a substantial contribution to the literature. Although Mojanoski and Bucevska (2022) investigate how EE stock markets react to the Russia-Ukraine war, they focus on stock market volatilities for a short period of time right after the war.

We find that while there exist unidirectional causal relationships from the Russian stock market to adjacent EE stock markets except only for the Romanian stock market in the pre-war period, there exists only one unidirectional causal relationship from the Russian stock market to the Bulgarian stock market in the post-war period and that causal relationship becomes even stronger. This means that the causal relationship between the Russian stock market and the Bulgarian stock market is strengthened after the war, whereas those between the Russian stock market and the other EE stock markets are weakened after the war. We also find that while extreme return co-movements between the Russian stock market and the Bulgarian stock market are strengthened after the war, those between the Russian stock market and the other EE stock markets are weakened after the war. As a result, our findings show that the recent Russia-Ukraine has had an asymmetric impact on the Bulgarian stock market and the other EE stock markets.

All data are described in Section 2, and methods and results are demonstrated in Section 3. Then, we summarize and conclude in Section 4.

2. Data

We obtain daily market index data for Russia (MOEX), Bulgaria (SOFIX), the Czech Republic (PX), Hungary (BUX), Poland (WIG), and Romania (BET) from investing.com. Our data set covers September 2021 to September 2022. Since the Russia-Ukraine war broke out on February 24, 2022, we use this date as a reference point to split the whole data period into two subperiods: the pre-war period from September 1, 2021, to February 24, 2022, and the post-war period from March 24, 2022, to September 30, 2022. The Russian stock market halted right after the war and resumed about a month later. Thus, our post-war period started on March 24, 2022. Each subperiod has approximately 6-month daily data. Figure 1 shows daily market index values for each market for both pre-and post-war periods. Overall, the indices' values decreased in the post-war period, and their patterns appear to be different across the pre-and post-war periods.

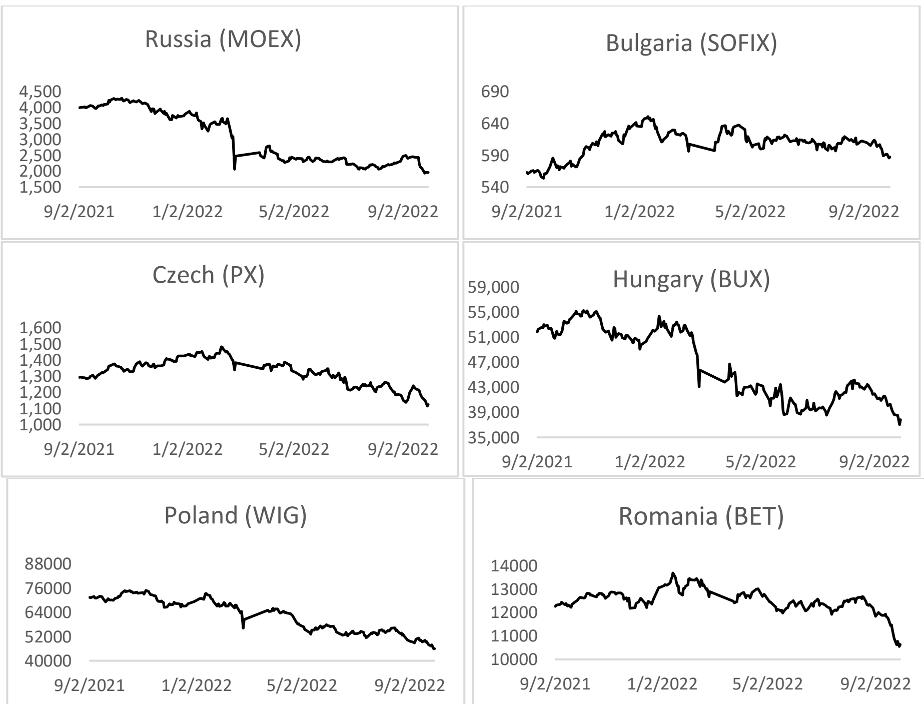

Figure 1. Daily Market Index Levels

3. Methods and Results

3.1. Causality

Since the purpose of our study is to examine the relationship between the Russian stock market and adjacent EE stock markets before and after the Russia-Ukraine war, we first analyze their short-run dynamics by investigating their causal relationships. To do this, first of all, the unit root test is conducted for all market indices in order to see if there is a unit root in their levels and log differences (returns). As shown in Dickey and Fuller (1979), the following equations are used for the unit root test.

$$\Delta r_t = \beta_0 + \beta_1 r_{t-1} + \sum_{j=1}^{n} \gamma_j \Delta r_{t-j} + \varepsilon_t \qquad (1)$$

$$\Delta r_t = \beta_0 + \beta_1 r_{t-1} + \beta_2 t + \sum_{j=1}^{n} \gamma_j \Delta r_{t-j} + \varepsilon_t \qquad (2)$$

where r_t is each market's index level or return. The null hypothesis is β_1= 0 (r_t has a unit root). While Equation (1) has no trend, Equation (2) has a trend. Throughout our study, we use the Bayes Information Criterion (BIC) to determine the optimal lag length. We show results using the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests.

Table 1. Unit root test

	Russia (MOEX)	Bulgaria (SOFIX)	Czech (PX)	Hungary (BUX)	Poland (WIG)	Romania (BET)
Panel A – Levels (ADF)						
CNT	-0.6677	-2.4247	0.1616	-0.4610	-0.2528	-0.0273
CT	-1.9568	-1.9561	-1.8813	-1.9127	-3.0779	-1.0720
Panel B – Levels (PP)						
CNT	-0.6844	-2.3678	-0.2363	-0.6242	-0.1941	-0.0832
CT	-2.4655	-1.9538	-1.9099	-2.3699	-3.0347	-1.1168
Panel C – Returns (ADF)						
CNT	-4.2709**	-4.4105**	-4.6103**	-3.5413**	-5.0592**	-3.0211*
CT	-4.2540**	-4.8806**	-5.2773**	-3.5845**	-5.1501**	-3.4165*
Panel D – Returns (PP)						
CNT	-17.7690**	-15.3390**	-13.1620**	-15.5860**	-15.9410**	-14.2130**
CT	-17.7380**	-15.4880**	-13.3540**	-15.5720**	-15.9880**	-14.4510**

Note: CNT stands for constant with no trend and CT stands for constant with trend. The following unit root test is used:
$\Delta r_t = \beta_0 + \beta_1 r_{t-1} + \sum_{j=1}^{n} \gamma_j \Delta r_{t-j} + \varepsilon_t$
$\Delta r_t = \beta_0 + \beta_1 r_{t-1} + \beta_2 t + \sum_{j=1}^{n} \gamma_j \Delta r_{t-j} + \varepsilon_t$
The null hypothesis is β_1= 0. The first equation has no trend and the second equation has a trend. * and ** indicate statistical significance at the 5% and 1% levels, respectively.

In Table 1, Panel A and Panel B show unit root test results for all indices' levels. All of them are not statistically significant, and thus, we fail to reject the null hypothesis. This means that all indices' levels have a unit root. In Panel C and Panel D, since all indices' returns are statistically significant, we reject the null hypothesis, and their returns have no unit root. Thus, all market indices are integrated into order one, I(1).

This means that we can use their returns to implement the Granger causality test between the Russian stock market and adjacent EE stock markets.

Table 2. Summary statistics for daily returns

	Russia (MOEX)	Bulgaria (SOFIX)	Czech Rep. (PX)	Hungary (BUX)	Poland (WIG)	Romania (BET)
Panel A – Full Sample Period						
Mean	-0.003238	0.000193	-0.000632	-0.001430	-0.002003	-0.000643
Standard Deviation	0.037588	0.008680	0.010885	0.018125	0.018293	0.010262
Skewness	-5.260631	-0.389350	-0.183323	-1.068965	-1.385360	-0.540059
Kurtosis	61.721828	0.971464	1.584720	6.517630	15.441361	1.823403
Panel B – Before the Russia-Ukraine War						
Mean	-0.006247	0.000539	0.000339	-0.001740	-0.002281	0.000309
Standard Deviation	0.044450	0.008742	0.008543	0.016055	0.017970	0.009762
Skewness	-7.111437	-0.439543	-1.238517	-3.127512	-4.198018	-0.186880
Kurtosis	62.434150	1.250713	5.564899	19.721169	30.444425	3.013721
Panel C – After the Russia-Ukraine War						
Mean	-0.002461	-0.000152	-0.001637	-0.001310	-0.003086	-0.001418
Standard Deviation	0.024062	0.008393	0.012158	0.018820	0.015849	0.010174
Skewness	-0.709469	-0.419343	0.163423	-0.267339	-0.156787	-0.717710
Kurtosis	2.620738	1.005942	0.412760	0.748109	0.902937	0.889230

Table 2 shows summary statistics for all indices' returns. While stock return volatilities in Russia, Bulgaria, and Poland decreased in the post-war period, those in the Czech Republic, Hungary, and Romania increased in the post-war period. Also, it seems that all markets' extreme returns (extreme losses) are relatively reduced in the post-war period except for the Romanian stock because of the increase and decrease in their skewness and kurtosis, respectively.

Next, we employ the following vector autoregressive (VAR) model to identify the causal relationships between the Russian stock market and the other EE stock markets.

$$\Delta x_t = a + \sum_{j=1}^{n} b_j \Delta x_{t-j} + \sum_{j=1}^{n} c_j \Delta y_{t-j} + \varepsilon_t \quad (3)$$

$$\Delta y_t = a + \sum_{j=1}^{n} b_j \Delta y_{t-j} + \sum_{j=1}^{n} c_j \Delta x_{t-j} + \varepsilon_t \quad (4)$$

where Δy_t is the return on the Russian stock market and Δx_t is the return on each of the other EE stock markets. The Bayes Information Criterion is used to determine the lag length. We calculate F-values from unrestricted and restricted equations for the null hypothesis that c_j is zero.

Table 3 shows the causality test results. In Panel A, the first null hypothesis of each test is rejected except for that of Test 5. This means that the Russian stock market Granger causes the other EE stock markets except for the Romanian stock market. However, we fail to reject the second null hypothesis of all tests. As a result, there exist unidirectional causal relationships from the Russian stock market to the other EE stock markets except only for the Romanian stock market in the pre-war period.

However, Panel B shows quite different results for the post-war period. Only the first null hypothesis of Test 1 is statistically significant and rejected even at the 1% significance level. All the other hypotheses are not rejected. Thus, there exists only one unidirectional causal relationship from the Russian stock market to the Bulgarian stock market in the post-war period. This means that while the causal relationship between the Russian stock market and the Bulgarian stock market was strengthened after the war, the causal relationships between the Russian stock market and the other EE stock markets were considerably weakened and almost disappeared after the war.

Table 3. Granger Causality Test Results

Null hypothesis		F-statistic
Panel A – Before the Russian-Ukraine War		
Test 1	ΔRussia (MOEX) does not Granger-cause ΔBulgaria (SOFIX)	3.54*
Russia (y_t)-Bulgaria (x_t)	ΔBulgaria (SOFIX) does not Granger-cause ΔRussia (MOEX)	0.18
Test 2	ΔRussia (MOEX) does not Granger-cause ΔCzech (PX)	9.56**
Russia (y_t)-Czech (x_t)	ΔCzech (PX) does not Granger-cause ΔRussia (MOEX)	0.29
Test 3	ΔRussia (MOEX) does not Granger-cause ΔHungary (BUX)	3.57*
Russia (y_t)-Hungary (x_t)	ΔHungary (BUX) does not Granger-cause ΔRussia (MOEX)	0.17
Test 4	ΔRussia (MOEX) does not Granger-cause ΔPoland (WIG)	14.30**
Russia (y_t)-Poland (x_t)	ΔPoland (WIG) does not Granger-cause ΔRussia (MOEX)	0.15
Test 5	ΔRussia (MOEX) does not Granger-cause ΔRomania (BET)	0.02
Russia (y_t)-Romania (x_t)	ΔRomania (BET) does not Granger-cause ΔRussia (MOEX)	0.01
Panel B – After the Russian-Ukraine War		
Test 1	ΔRussia (MOEX) does not Granger-cause ΔBulgaria (SOFIX)	5.06*
Russia (y_t)-Bulgaria (x_t)	ΔBulgaria (SOFIX) does not Granger-cause ΔRussia (MOEX)	0.53
Test 2	ΔRussia (MOEX) does not Granger-cause ΔCzech (PX)	1.06
Russia (y_t)-Czech (x_t)	ΔCzech (PX) does not Granger-cause ΔRussia (MOEX)	0.01
Test 3	ΔRussia (MOEX) does not Granger-cause ΔHungary (BUX)	0.11
Russia (y_t)-Hungary (x_t)	ΔHungary (BUX) does not Granger-cause ΔRussia (MOEX)	0.01
Test 4	ΔRussia (MOEX) does not Granger-cause ΔPoland (WIG)	0.06
Russia (y_t)-Poland (x_t)	ΔPoland (WIG) does not Granger-cause ΔRussia (MOEX)	0.45
Test 5	ΔRussia (MOEX) does not Granger-cause ΔRomania (BET)	0.10
Russia (y_t)-Romania (x_t)	ΔRomania (BET) does not Granger-cause ΔRussia (MOEX)	0.25

Note: The following equations (VAR model) are used:

$$\Delta x_t = a + \sum_{j=1}^{n} b_j \Delta x_{t-j} + \sum_{j=1}^{n} c_j \Delta y_{t-j} + \varepsilon_t$$

$$\Delta y_t = a + \sum_{j=1}^{n} b_j \Delta y_{t-j} + \sum_{j=1}^{n} c_j \Delta x_{t-j} + \varepsilon_t$$

F-values are calculated from unrestricted and restricted equations. The null hypothesis is cj=0. The lag length is determined by the Bayes Information Criterion. The lag length for Tests 1, 2, 4, and 5 is 1, and the lag length for Test 3 is 2.

* and ** indicate statistical significance at the 5% and 1% levels, respectively.

3.2. Extreme Return Co-movements

In this section, we examine extreme return co-movements between the Russian stock market and the other EE stock markets. The relationship between two assets in a normal time can be completely different from their relationship in a bad time.

We adopt a copula approach to explain extreme return co-movements. Copulas are often used to model bivariate or multivariate distributions. So, we can employ them to estimate how two assets' extreme returns behave simultaneously.

According to Klugman et al. (2008) and Sklar's theorem, a multivariate copula is the joint distribution of Uniform random variables (*U1, U2, …., Ui*). There exists a unique copula *W* for any joint distribution function *H,* and the copula satisfies the following equations.

$$W(u_1, u_2, \ldots\ldots, u_i) = \Pr(U_1 \leq u_1, U_2 \leq u_2, \ldots\ldots, U_i \leq u_i) \quad (5)$$

where $U_i \sim U(1, 0)$.

$$H(x_1, x_2, \ldots\ldots, x_i) = \mathrm{W}\big(H_1(x_1), H_2(x_2), \ldots\ldots, H_i(x_i)\big) \quad (6)$$

Therefore, a multivariate joint distribution can be constructed with a defined copula and marginal distributions. The Archimedean copula is one type of copula and can be readily defined with a specific generator. The Archimedean copula has the following fundamental form.

$$W(u_1, u_2, \ldots\ldots, u_i) = \eta^{-1}(\eta(u_1) + \eta(u_2) + \cdots\cdots + \eta(u_i)) \quad (7)$$

where $\eta(u)$ is a generator. Since we attempt to examine how extreme returns on the Russian stock market and the other EE stock markets move simultaneously, we adopt a bivariate Archimedean copula. It is common to have dependence measures associated with the copula. The most popular dependence measure is Kendall's tau (τ), and it has a mathematical link with Archimedean copulas. The relationship between Kendall's tau and the copula function W is derived with the following equation.

$$\tau(\mathrm{X}, \mathrm{Y}) = 4 \int_0^1 \int_0^1 W(u_1, u_2) w(u_1, u_2) du_1 du_2 - 1 \quad (8)$$

where $w(u_1, u_2) = \frac{\partial^2 W(u_1, u_2)}{\partial u_1 \partial u_2}$. Assuming the extreme market condition, we use the Clayton copula, which is one of the asymmetric Archimedean copulas and has greater dependence weight on the negative tail. The Clayton copula for a bivariate vector is also well described by Baek (2020). It is constructed as follows.

$$W(u_1, u_2) = Max[(u_1^{-\phi} + u_2^{-\phi} - 1)^{-1/\phi}, 0\,] \quad (9)$$

$$\tau = \phi/(2 + \phi) \quad (10)$$

where $\eta(\mathrm{u}) = -\frac{1}{\phi}\left(1 - u^{-\phi}\right)$ and ϕ is the dependence parameter. Table 4 shows copula probabilities calculated based on Equation (9) and Equation (10). The lowest NP is the probability that two returns fall within their lowest Nth percentiles at the same time.

Table 4. Copula Probabilities

Bivariate Vectors	Lowest 1P	Lowest 2.5P	Lowest 5P
Panel A – Before the Russia-Ukraine War			
(ΔRussia, ΔBulgaria)	0.00034	0.00143	0.01421
(ΔRussia, ΔCzech)	0.00520	0.01307	0.05404
(ΔRussia, ΔHungary)	0.00533	0.01340	0.05517
(ΔRussia, ΔPoland)	0.00633	0.01583	0.06390
(ΔRussia, ΔRomania)	0.00338	0.00879	0.03984
Panel B – After the Russian-Ukraine War			
(ΔRussia, ΔBulgaria)	0.00077	0.00260	0.01905
(ΔRussia, ΔCzech)	0.00060	0.00217	0.01737
(ΔRussia, ΔHungary)	0.00000	0.00005	0.00459
(ΔRussia, ΔPoland)	0.00083	0.00276	0.01966
(ΔRussia, ΔRomania)	0.00037	0.00152	0.01464

Panel A shows results for the pre-war period. While the probability that returns on the Russian stock market and the Bulgarian stock market fall within their lowest 1st percentiles at the same time is the smallest (0.00034), the probability that returns on the Russian stock market and the Polish stock market fall within their lowest 1st percentiles at the same time is the largest (0.00633). For the lowest 2.5P and 5P, we have the same results. This means that under extreme market conditions, the Bulgarian stock market is least likely to co-move with the Russian stock market, and the Polish stock market is most likely to co-move with the Russian stock market. In Panel B, the post-war results are a little different. While the Polish stock market is still most likely to co-move with the Russian stock market, the Hungarian stock market is least likely to co-move with the Russian stock market.

More importantly, we need to see the impact of the war on extreme return co-movements between the Russian stock market and the other EE stock markets. Comparing Panel A and Panel B, we find that only the Bulgarian stock market's probabilities increase in the post-war period (0.00034 to 0.00077 for the lowest 1P, 0.00143 to 0.00260 for the lowest 2.5P, and 0.01421 to 0.01905 for the lowest 5P). Thus, extreme return co-movements between the Russian stock market and the Bulgarian stock market appeared to be strengthened after the war. However, all the other market's probabilities significantly decreased in the post-war period, which means that their extreme return co-movements were weakened after the war. In fact, the results of this copula test are consistent with those of our causality test in the sense that the relationship between the Bulgarian stock market and the Russian stock market is strengthened after the war.

4. Conclusion

In this study, we investigate the impact of the recent Russia-Ukraine war on the relationships between the Russian stock market and adjacent Eastern European (EE) stock markets (Bulgaria, Czech Republic, Hungary, Poland, and Romania). In particular, identifying any change in their relationships after the war would be critical in terms of stock portfolio diversification.

First, we examine short-run causal relationships between the Russian stock market and adjacent EE stock markets. In the pre-war period, there existed unidirectional causal relationships from the Russian stock market to adjacent EE stock markets except only for the Romanian stock market. However, in the post-war period, there existed only one unidirectional causality from the Russian stock market to the Bulgarian stock market, and that causality became even stronger. This means that while the war has a positive impact on the causal relationship between the Russian stock market and the Bulgarian stock market, it has a negative impact on the causal relationships between the Russian stock market and the other EE stock markets.

Second, we investigate extreme return co-movements between the Russian stock market and adjacent EE stock markets using the copula approach. We find that extreme return co-movements between the Russian stock market and the Bulgarian stock market are strengthened after the war, whereas those between the Russian stock market and the other EE stock markets are weakened after the war.

In summary, based on short-run causal relationships and extreme return co-movements, it appears that the recent Russia-Ukraine war has an asymmetric impact on the EE stock markets. Only the relationship between the Russian stock market and the Bulgarian stock market is strengthened after the war. The other EE stock markets' relationships weakened or disappeared after the war. This has a critical implication in the sense that an investment in the Bulgarian stock market has no diversification effect when the Russian stock market crash is triggered by an extreme event. Since the EE stock markets are considered emerging markets in the same region for the purpose of investment, this finding shows how stock market investors diversify their portfolios during the Russian market downturn.

Lastly, our study has a limitation. We need further research in order to clarify why the war has an asymmetric impact on the Bulgarian stock market and the other EE stock markets. Nevertheless, our study is expected to provide new insight into stock market participants.

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