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The shock of war: do trade relations impact the reaction of stock markets to the Russian invasion of Ukraine?

1. Introduction

The stock market is a barometer of the economy, and stock prices may serve as a barometer of economic prospects, social movements, and general sentiment (Ratcliffe, Taylor, 2015). It has long been known that stock market shares are sensitive to current information and can even overreact to unexpected and dramatic events (De Bondt, Thaler, 1985; Joerding, 1988). Numerous studies demonstrate the adverse relationship between a variety of unexpected, catastrophic events, such as earthquakes (Shelor et al., 1990), hurricanes (Lamb, 1995), airline crashes (Barrett et al., 1987), and terroristic attacks (Carter, Simkins, 2004). Major public health threats, including SARS, MERS, COVID-19, and even influenza, also affect stock markets (Chen et al., 2007; McTier et al., 2013; Zhang et al., 2020; Czech et al., 2020; Goodell, 2020). Nevertheless, unlike other black swan events, wars have an increased tendency to influence global stock markets (Adekoya et al., 2023).

The effects of international military conflicts on financial markets, particularly stock prices, have been studied since the second half of the 20th century (Schneider, Troeger, 2006; Hudson, Urquhart, 2015). Brune et al. (2015) have analysed the stock market reaction to large military conflicts since WWII, including the Vietnam War, the Gulf War, and the Afghanistan War. They conclude that stock market prices are sensitive to the probability of a war breaking out and that they

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react adversely to this prospect. Leigh et al. (2003) observe that the Iraq war affected the U.S. equity market by approximately 15 percent. Cutler et al. (1988) assess the stock market reaction to major political and world news, including wars, from 1926 to 1985. Rigobon and Sack (2005) and Smith (2014), having analysed the war in Iraq, observe that stock markets respond to the increasing likelihood of war and even to news of an upcoming international military conflict. The key finding is that stock market prices are sensitive to the probability of a war breaking out and that they react adversely to this prospect.

This paper focuses on stock markets reactions to the Russian invasion of Ukraine on 24 February 2022. This was an escalation of a conflict that had been ongoing since February 2014. The casus belli is the official status of Crimea and Donbas. The full-scale Russian invasion between the neighbours (Umar et al., 2022), and has resulted in the worst military conflict in Europe since the Yugoslav Wars of the 1990s (Astrov et al., 2022). This conflict has destabilised and exacerbated imbalances in the global economic and political order (Mariotti, 2022). The resulting geopolitical risks have adversely stock market prices (Ahmed et al., 2022; Alam et al., 2022; Będowska-Sójka et al., 2022; Diaconaşu et al., 2022; Sun, Zhang, 2022). According to Alsayed (2022), the impact of the Russian invasion of Ukraine on stock markets has been heterogenous and depends on a country's economic relations with, and distance from, the belligerents. Karamti and Jeribi (2022) show that the impact of the Russian aggression towards Ukraine on equity markets has been heterogeneous across countries and that this is mainly due to their economic and political relations and/or their distance from the war zone. Moreover, they confirm that markets in developed economies that are extremely dependent on commodities are most sensitive to, and affected by, the Russo-Ukrainian military conflict. Boungou and Yatie (2022), based on a panel model for data covering 94 countries between 22 January and 24 March 2022, find the most substantial and adverse stock market reactions in countries geographically close to the Russia-Ukraine conflict. Umar et al. (2022) show that the Russian invasion of Ukraine has triggered changes in the dynamic relationships among financial markets, most notably market shocks induced by the increased geopolitical risk. Boubaker et al. (2022) study the impact of the Russian invasion on stock market indices around the world by applying cross-sectional analyses for event-day and post-event returns. They use GDP-scaled trade as a measure of economic globalization and find that developed markets have reacted more strongly and negatively than emerging markets. Lo et al. (2022) obtain similar results, and show that developed markets are more affected than emerging markets and that the effect is positively correlated to dependence on Russian commodities. Yousaf et al. (2022), by applying the event-study approach based on the OLS model for the G20 and other selected countries, observe a significant and adverse stock market reaction to the Russian invasion of Ukraine on the event day and on post-event days. They observe the most substantial stock market reaction in Russia, Poland, Hungary, and Turkey on the event day. Federle et al. (2022) analyse the stock market reaction to the Russian invasion of Ukraine in 66 countries and find that changes in stock market prices during a four-week window around the start

of the war are linked to a country's distance from Ukraine. Deng et al. (2022) find that the diverse reactions of U.S. and European stock prices were induced by the expectation of stronger policy responses and the quest for alternatives to Russian oil and gas on the part of European importers. However, Berninger et al. (2022) find no evidence that the stock market reaction of firms is affected by their country of origin or their distance from Ukraine or Russia.

This paper adopts the assumption that the stock price effect in a given country is positively correlated to the strength of that country's trade ties with either or both of the belligerents. To our knowledge, no other studies have assessed the impact of the Russian invasion of Ukraine on stock market indices by taking cognisance of trade links. Moreover, contrary to other research studies, we first distinguish clusters representing countries with a similar share of trade with Russia and Ukraine. On the basis of these cluster data, we assess whether there are significant differences in stock market reactions between selected groups of countries.

The outline of our paper is as follows. The next section presents the research methodology, the section following that sets out and discusses the empirical findings, and the final section posits conclusions.

2. Methodology

This paper assesses whether the strength of trade ties with Russia and Ukraine differentiates the reaction of a given country's stock market to the outbreak of the Russian invasion of Ukraine. EU member states and the G20 are both examined. Altogether, the analysis encompasses 42 countries.

The k-means clustering developed by Linde et al. (1980) was used to cluster countries according to the share of their foreign trade conducted with Ukraine and Russia. The k-means method aims to find the nearest distance of points from the cluster's centre (Ding, He, 2004; Zalik, 2008). The technique is helpful in numerical segmentation of economic data and was introduced by MacQuenn (1967). The number of clusters is based on Dunn's connectivity-based cluster validity index. Saha and Bandyopadhyay (2012) compared seven cluster validity indices, viz. the DB-index, Dunn-index, Generalized Dunn-index, PS-index, I-index, XB-index and SV-index. The results show that the connectivity-based Dunn-index performs the best.

Given a dataset $C = \{x_1, \dots, x_n\}$ with n samples and m features. k-means clustering aims to minimise the following function:

$$F(U, Z) = \sum_{h=1}^{k} \sum_{i=1}^{n} \sum_{j=1}^{m} u_{ih} \times c\left(x_{ij}, z_{hj}\right) \tag{1}$$

where k represents the number of clusters; $U = [u_{ih}]$ is an $n \times k$ partition matrix that satisfies $u_{ih} \in \{0,1\}$ and $\sum_{h=1}^{k} u_{ih} = 1 (1 \leq i \leq n; 1 \leq h \leq k)$; $Z = \{Z_h, h = 1, \dots k\}$ is a set of cluster centres in which Z_h consists of m values

$\left(z_1^h, z_2^h, \ldots, z_m^h\right)$, each is the mean of a feature j in cluster Z_h and is defined as $z_j^h = \frac{\sum_{x_i \in Z_h} x_{ij}}{|Z_h|}$; while $c(\cdot,\cdot)$ is the squared Euclidean between two feature values.

In the present study, n is the number of G20 and EU countries and equals 42, while m equals four and represents the following clustering variables: these countries' export shares to Russia; their import shares from Russia; their export shares to Ukraine; and their import shares from Ukraine (Equation 1). The variables were standardised prior to clusteringin order to compareable between the G20 and the EU countries . Table 1 depicts the data applied in the clustering.

Table 1

G20 and EU member states' trade share with Russia and Ukraine, and their leading stock exchange indices

Country	Russia		Ukraine		Stock exchange index
	Export share (%)	Import share (%)	Export share (%)	Import share (%)	
Argentina[a]	0.89	1.10	0.05	0.03	S&P Merval
Australia[a]	0.07	0.15	0.04	0.04	S&P/ASX 200
Austria*	1.20	0.35	0.39	0.48	ATX
Belgium*	0.99	1.80	0.18	0.15	BEL20
Brazil[a]	0.73	1.79	0.07	0.05	Ibovespa
Bulgaria*	1.50	6.20	0.83	1.90	SOFIX
Canada[a]	0.10	0.35	0.04	0.04	TSX 300
China[a]	2.10	3.20	0.29	0.40	SSE Composite
Croatia*	1.10	1.60	0.30	0.16	CROBEX
Cyprus*	2.20	1.00	0.37	0.25	CSE General Index
Czech Republic*	1.90	3.00	0.71	0.88	PX Index
Denmark*	0.97	1.90	0.39	0.28	OMXC25
Estonia*	6.50	13.0	0.89	0.70	OMXT
Finland*	5.21	9.84	0.33	0.12	OMXH25
France*,[a]	1.30	1.60	0.25	0.12	CAC40
Germany*,[a]	2.00	2.00	0.40	0.27	DAX
Greece*	0.53	6.90	0.86	0.32	FTSE/Athex Large Capi
Hungary*	1.50	3.10	2.30	1.50	BUX
India[a]	0.85	1.50	0.13	0.46	NIFTY 50
Indonesia[a]	0.67	0.65	0.19	0.54	IDX Composite
Ireland*	0.28	0.36	0.05	0.11	ISEQ 20
Italy*,[a]	1.50	3.80	0.42	0.70	FTSE MIB
Japan[a]	1.10	1.90	0.08	0.10	Nikkei225
Latvia*	7.30	9.10	1.40	1.20	OMXRGI
Lithuania*	11.00	12.00	3.80	1.20	OMXVGI
Luxembourg*	1.10	0.18	0.10	0.26	LuxX Price
Malta*	0.19	0.26	0.10	0.09	MSE Equity Price Index

Country	Russia		Ukraine		Stock exchange index
	Export share (%)	Import share (%)	Export share (%)	Import share (%)	
Mexico[a]	0.10	0.45	0.01	0.04	IPC
Netherlands*	1.20	3.70	0.23	0.42	AEX index
Poland*	2.80	6.10	2.20	1.50	WIG20
Portugal*	0.28	1.30	0.06	0.36	PSI-20
Romania*	1.40	4.80	0.95	1.40	BET
Saudi Arabia[a]	0.09	0.53	0.08	0.49	Tadawul All Share (TASI)
Slovakia*	1.50	7.00	0.88	0.98	SAX
Slovenia*	2.20	0.96	0.62	0.21	SBI TOP
South Africa[a]	0.50	0.79	0.02	0.05	FTSE/JSE All Share Index
South Korea[a]	1.40	2.40	0.08	0.14	KOSPI
Spain*	0.71	1.80	0,22	0.46	IBEX 35
Sweden*	1.40	1.30	0.30	0.06	OMXS30
Turkey[a]	2.60	12.0	1.30	1.80	BIST 30
United Kingdom[a]	0.86	3.70	0.19	0.17	FTSE 100
United States[a]	0.37	1.10	0.15	0.07	DJIA

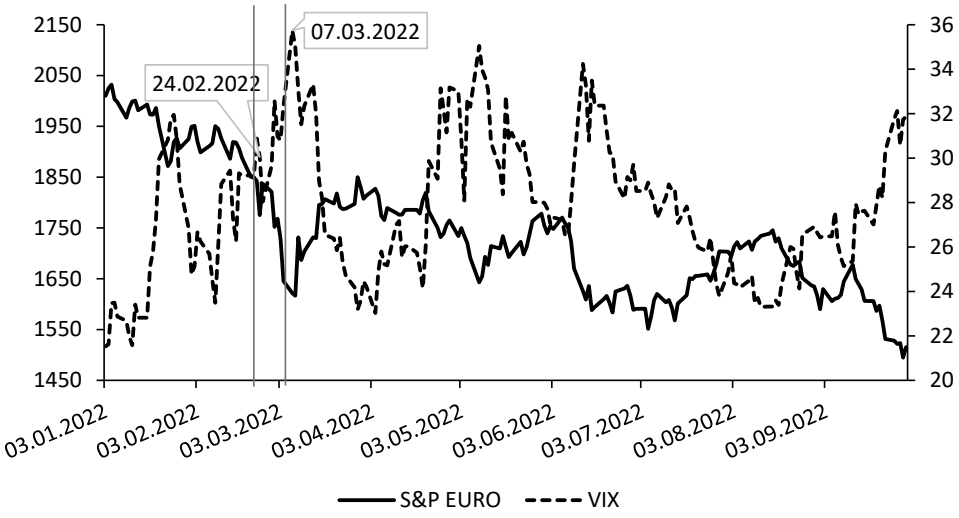
[a] G20 member; * EU member state

Source: own calculation and elaboration based on Trading Economics and countries' leading stock exchanges official websites.

The analysis is based on two data sources. The clustering is based on 2021 Trading Economics data on the analysed countries' foreign trade shares with Russia and Ukraine. These data are standardised in the clustering analysis. The stock market reactions to the outbreak of the Russian invasion of Ukraine are based on daily data from Refinitiv Datastream. The reaction in a given country is calculated as the percentage changes in the values of that country's leading stock market indices. A one-day index change on the first day of the invasion (Y1) and the index change between 23 February and 7 March 2022 (Y2) are estimated. The latter date (7 March) refers to the highest level of stock market uncertainty following the outbreak of the invasion, as reflected in the maximum level of the S&P option-implied volatility index (VIX). This reflects the highest level of stock market uncertainty in the aftermath of the Russian invasion of Ukraine (Figure 1).

Figure 1

VIX and S&P EURO in January-September 2022



Source: own elaboration based on Refinitiv Datastream.

The present study analyses the one-day stock market index change on the first day of the Russian invasion of Ukraine, and the stock market index change between 23 February and 7 March 2022, similarly to Yousaf et al. (2022). However, in contrast to their research, the relationship between the strength of countries' trade ties with Russia and Ukraine and the magnitude of their stock price reactions are analysed in addition to changes in stock market indices.

This paper assumes that countries with close economic ties to Russia and Ukraine have experienced more extensive negative changes in their stock market indices. Table 1 presents the leading stock exchange indices in each of the analysed countries.

The existence of significant differences in the median changes of leading stock market indices between clusters following the Russian invasion of Ukraine was verified and assessed by applying the Kruskal-Wallis test (Kruskal, 1952; Kruskal, Wallis, 1952) and Wilcoxon's rank-sum pairwise comparison test (Wilcoxon, 1992), with the adjustment based on the Benjamini and Hochberg method (Benjamini, Hochberg, 1995). In the Kruskal-Wallis test, percentage changes in the value of the two indices (Y1 and Y2) represent the quantitative variable. The distinguished clusters refer to the qualitative variable.

The null (H_0) and alternative (H_1) hypotheses in the Kruskal-Wallis test are as follows (Hecke, 2012; Ostertagová et al., 2014):

H_0: *All k population medians are the same.*

H_1: *At least two population medians differ.*

A calculation of the test statistic in the Kruskal-Wallis test is presented below:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1), N = \sum_{i=1}^{k} n_i \quad (2)$$

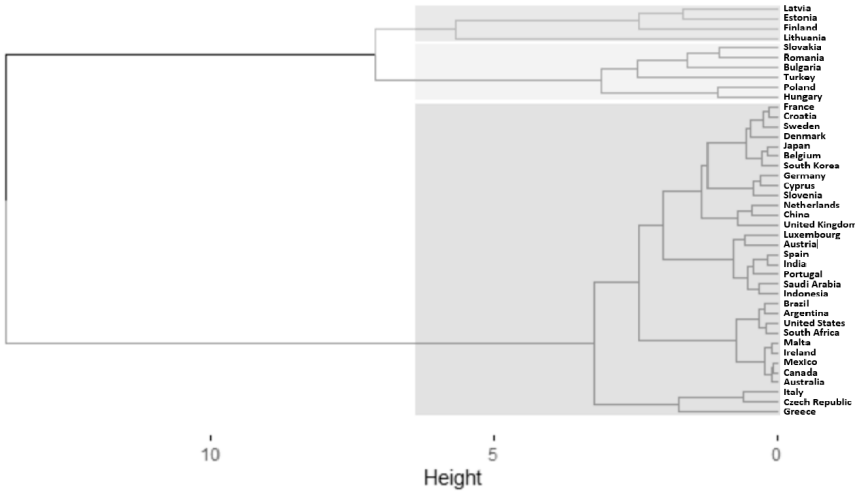
where R_i is the sum of the ranks calculated for each group i ($i = 1, 2, \ldots, k$), n_i is the size of i group, and N is the number of observations in all k groups. H is approximately χ^2 distributed, with $k - 1$ degrees of freedom. The coefficient $\frac{12}{N(N+1)}$ is a suitable normalization factor.

3. Research results and discussion

The clustering analysis is based on the k-means algorithm for the four selected variables mentioned above (i.e. the import and export shares with Russia and Ukraine). Dunn's connectivity-based cluster validity index reveals that the optimal number of clusters is three. The dendrogram (Figure 2) depicts clusters in which countries are combined on the basis of their trade relations with Russia and Ukraine. Cluster I comprises Latvia, Estonia, Finland, and Lithuania. Cluster II comprises Slovakia, Romania, Bulgaria, Turkey, Poland, and Hungary. Cluster III comprises France, Croatia, Sweden, Denmark, Japan, Belgium, South Korea, Germany, Cyprus, Slovenia, the Netherlands, China, the United Kingdom, Luxembourg, Austria, Spain, India, Portugal, Saudi Arabia, Indonesia, Brazil, Argentina, the United States, South Africa, Malta, Ireland, Mexico, Canada, Australia, Italy, the Czech Republic, and Greece.

Figure 2

k-means clustering results



Source: own calculation and elaboration based on Trading Economics and the official websites of the national stock exchanges of the countries involved.

Table 2 reveals that cluster I, which comprises four of the five EU member states bordering Russia, has the strongest trade ties to that country. Cluster I's average export and import shares to and from Russia are 7.5% and 11% respectively. This is also the group whose export share to Ukraine is greatest. Cluster II, which comprises five EU member states and Turkey, has the greatest import share from Ukraine, as well as a high import share from Russia. Cluster III comprises countries whose trade ties with Russia and Ukraine are minor.

Table 2

Average values of analysed variables in distinguished clusters

Variable	Cluster I	Cluster II	Cluster III
Export share to Russia (%)	7.50	1.88	0.96
Import share from Russia (%)	10.99	6.53	1.67
Export share to Ukraine (%)	1.61	1.41	0.23
Import share from Ukraine (%)	0.81	1.51	0.26
Event day change in stock market index value (%)	-3.63	-6.89	-2.98
Post-event days change in stock market index value (%)	-14.33	-9.99	-6.14

Source: own calculation and elaboration based on Trading Economics and the official websites of the national stock exchanges of the countries involved.

On average, leading stock indices from Cluster II countries reacted most strongly on the first day of the Russian invasion. On the other hand, Cluster I countries recorded the most significant decreases in stock market indices during the first days of the war (i.e. until 7 March 2022) (Table 2). This might have been driven by the policy of sanctions and the growing aversion to Russia in these countries. Whether there are significant differences in the stock market reactions of the three clusters was then verified. The Kruskal-Wallis test results imply significant differences in the median changes in the values of leading stock market indices between at least two of the three distinguished clusters, at the 5 and 10 significance levels for Y1 (a one-day index change on the first day of the Russian invasion) and Y2 (the index change between 23 February and 7 March 2022), respectively (Table 3). A pairwise comparison test was additionally conducted to verify whether the significant differences in median values applied to all three clusters. Following multiple comparisons, the p-values were corrected in the post hoc analysis using the Benjamini-Hochberg method.

Table 3

Kruskal–Wallis and Wilcoxon rank-sum pairwise comparison tests results

Kruskal-Wallis test		
Statistical measures	Y1	Y2
chi-square	5.374	6.889
p-value	0.068	0.032
Wilcoxon rank-sum pairwise comparison test (p-value)		
Clusters	Y1	Y2
I-II	0.429	0.410
I-III	0.543	0.030
II-III	0.064	0.370

Source: own calculation and elaboration based on Trading Economics and the official websites of the national stock exchanges of the countries involved.

The event day stock market reaction to the war outbreak in countries included in cluster II is the strongest and significantly different than in cluster III at a 10% significance level. The analysis of stock market response during post-event days, i.e., between 23.02.2022 and 07.03.2022, indicates a difference between clusters I and III that is statistically significant at the 5% level.

These results correspond to those of Bougou and Yatie (2022), who observe that countries bordering Russia and Ukraine have experienced the greatest negative stock market reactions to the Russian invasion. Moreover, the results are consistent with those of Federle et al. (2022) and Karamti and Jeribi (2022), who find that a country's distance from Ukraine significantly impacts its stock market reaction to the Russian invasion. However, they do not confirm the findings of Boubaker et al. (2022), which reveal that the financial markets in developed countries were more adversely and heavily affected than emerging markets on event day and post-event days.

In comparison to our results, Yousaf et al. (2022) observe the most substantial stock market reactions in Russia, Poland, Hungary, and Turkey on the event day. However, they analyse the stock market reactions in individual countries separately. Moreover, they do not consider Estonia, Finland, Lithuania, and Latvia, and it was these countries that reacted most strongly on 24 February.

Overall, the results of the present study reveal that the countries with the closest trade ties to the belligerents experienced the strongest and most adverse stock market reactions.

4. Conclusions

The outbreak of war invariably triggers a fall in stock market prices and the Russian invasion of Ukraine has been no exception. The invasion has led to substantial short-term declines in stock market indices all over the world. This paper

additionally assumes that the stock market reaction has varied across countries and is related to the strength of a given country's trade ties with the belligerents.

The 42 G20 and EU countries were grouped into three clusters on the basis of four variables related to their import and export shares with Russia and Ukraine. Cluster I comprises those countries whose trade links with Russia are strongest. Cluster II consists of countries whose average import shares with Ukraine are greatest. Cluster III comprises countries whose trade ties with Russia and Ukraine are weakest.

The strength of trade ties with Russia and Ukraine are shown to significantly differentiate the reactions of stock market indices to the outbreak of the invasion. Those countries whose economic links to Russia and Ukraine are strongest experienced the largest stock market index declines on the event day (23–24 February 2022) and on post-event days (23 February–7 March 2022).

These findings imply that the scale of economic relations between countries play an important role in the magnitude of stock market reactions to the outbreak of international military conflicts, particularly these days when financial markets are globally integrated.

The results of this study should be assessed more broadly than in terms of its stated main objective, i.e. to determine whether the strength of trade ties with Russia and Ukraine has differentiated stock market reactions to the outbreak of the Russian invasion. This study further aims to gauge the level of economic sensitivity to the outbreak of this military conflict by assuming that the strength of a country's relationship with either or both belligerents is positively correlated to the extent of its adverse stock market reaction. The present research is focused on analysing trade links and the reactions of leading stock market indices. This is warranted on the basis that trade links are a useful measure of economic relations and the stock market is a barometer of the economy; one that immediately reflects the economic prospects induced by external shocks.

The authors are fully aware that this study suffers from certain drawbacks and limitations. Firstly, it cannot be considered global. Nevertheless, it presents a broad perspective in that it is based on the largest world economies (G20) and all EU member states. Secondly, by assessing the reaction of the leading stock market indices in the analysed countries, the focus has been on general, rather than sector-specific, stock market reactions. These can reveal a more detailed picture of the stock market changes induced by this military conflict.

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THE SHOCK OF WAR: DO TRADE RELATIONS WEIGH ON THE REACTION OF STOCK MARKETS TO THE RUSSIAN INVASION OF UKRAINE?

Abstract

This paper assesses whether the strength of trade ties with Russia and Ukraine differentiates the reaction of stock markets to the outbreak of the Russian invasion of Ukraine on 24 February 2022. Both the G20 and the EU are studied. The focus is on the stock market index change on the first day of the invasion, and the stock market index change between 23 February and 7 March 2022, where 7 March refers to the highest level of stock market uncertainty following the outbreak of the conflict. We distinguish clusters representing countries with a similar share of trade with Russia and Ukraine and then,

based on cluster data and the Kruskal-Wallis and Wilcoxon rank-sum pairwise comparison tests, assess whether there are significant differences in stock market reactions between selected groups of countries. We reveal that the level of a country's trade links with the belligerents of the conflict significantly impacts changes in its stock market indices. Indices from those countries whose ties to Russia and Ukraine are strongest have decreased the most. This study therefore implies that the scale of economic relations between countries might play an important role in the magnitude of the stock market reaction to the outbreak of an international military conflict, particularly these days when financial markets are globally integrated.

Keywords: European Union, trade, Russian invasion of Ukraine, stock market index, G20

JEL: F40, F51, G15

REAKCJA RYNKÓW GIEŁDOWYCH NA INWAZJĘ ROSJI NA UKRAINĘ A POWIĄZANIA HANDLOWE ZE STRONAMI KONFLIKTU

Streszczenie

Celem artykułu jest sprawdzenie, czy siła powiązań handlowych z Rosją i Ukrainą istotnie różnicuje reakcję giełd papierów wartościowych na militarną agresję Rosji na Ukrainę 24 lutego 2022 r. Zakres podmiotowy badania stanowią wszystkie kraje G20 oraz Unii Europejskiej. W badaniu skoncentrowano się na jednodniowej zmianie indeksu giełdowego w pierwszym dniu inwazji oraz zmianie indeksu giełdowego w okresie od 23 lutego do 7 marca 2022 r. Data 7 marca 2022 r. odnosi się do najwyższego poziomu niepewności giełdowej w następstwie wybuchu analizowanego konfliktu zbrojnego. Na podstawie analizy skupień metodą k-średnich wyodrębniono trzy klastry reprezentujące kraje o podobnym udziale w handlu z Rosją i Ukrainą. Następnie, wykorzystując test Kruskala-Wallisa oraz test rang Wilcoxona, zweryfikowano, czy istnieją istotne różnice w reakcjach giełd między wyodrębnionymi grupami krajów. Zaobserwowano, że poziom powiązań handlowych kraju ze stronami konfliktu istotnie różnicuje reakcje indeksów giełdowych. Największe spadki wartości notują wiodące indeksy giełdowe z krajów najbardziej powiązanych gospodarczo z Rosją i Ukrainą. Wyniki badań wskazują na to, że poziom relacji gospodarczych między krajami może mieć istotny wpływ na reakcję indeksów giełdowych na wybuch międzynarodowych konfliktów zbrojnych, w szczególności w okresie globalizacji rynków finansowych.

Słowa kluczowe: Unia Europejska, handel, indeks giełdowy, inwazja Rosji na Ukrainę, G20

JEL: F40, F51, G15