Commodity market and G7 indices: geopolitical risk and spillover

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Abstract

The economies of each State are increasingly interconnected and depend on international trade not only for sales markets but above all for the supply of raw materials necessary for the functioning of the production complex of each countries. Alongside oil and gold, the main commodities traded include industrial metals, such as aluminium and copper, mineral products such as gas, electrical and electronic components, agricultural products and precious metals. The intricate set of connections and transactions was put to the test during the conflict between Russia and Ukraine given that these are countries with notable raw materials and strongly dedicated to exports. This suggested that commodity prices were able to influence the stock markets, especially in the countries most closely linked to the two belligerents in terms of import-export. The BEKK and VECM models were used to analyze whether volatility affects stock markets. The results show that lagged shocks and volatility significantly and positively influence the current conditional volatility of commodities and stock returns during all periods. In fact, the past shocks inversely influence the current volatility of stock indices in period when external events disrupt financial markets. The Granger causality test shows the presence of cointegration relationships and non-linear and positive impact of commodity volatilities on the implied volatility of the stock marlets. The findings suggest that the war significantly effected stock prices and exacerbated volatility, then the investors should diversify their portfolios to maximize returns and reduce risk differently in time of crisis.

Keywords: Commodity markets, Volatility, Multivariate GARCH, Russia-Ukraine conflict

JEL Classification: G01, G13, G15, C32

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1 Introduction

On February 24, 2022 the diplomatic-military clash between Russia and Ukraine, which began eight years earlier in February 2014, worsened and resulted in an invasion of some Ukrainian territories. The war in Ukraine, with like all wars have not only military but also humanitarian and economic consequences, has caused alarming effects on the world economy, particularly in the initial stages. Developing countries are those that have seen a particularly dramatic impact. In fact, the two countries are among the granaries of the world and together they supply around 30 percent of the wheat and barley respectively, a fifth of the corn and almost 70 percent of the sunflower oil [1]. In addition to this the Russian Federation and Ukraine are among the main exporters of natural gas, oil, cast iron, enriched uranium, palladium, and nickel. Furthermore, it has a significant share in the exports of coal, platiunum and refined aluminum. Among other commodities, Ukraine is the world's larger exporters of sunflower oil and neon gas, which is a key imput used to produce electronic chips. Finally, these two countries together with Belarus are important suppliers of fertilizers, including nitrogen and potassium. In 2022 Russia exports mineral fuels, oils and product of its distillation for approximately $313B, metals for $37B and precious stone for $30B. Ukraine exports cereals and animal or vegetable oil for approximately $20B, metals and mineral products for $13B and electrical machinery and mechanical appliances for $5B. If we compare the values with those of the year before the war, Russia notes an increase in exports of mineral fuels of 22.3%, of aluminium of 3.8% and of almost of 7% of copper. While exports of iron and steel decreased by 32.5%, precious stones by 25.6% and cereals by 41%. Ukraine is more affected by the consequences of the war. In fact, compared to a growth in exports of mineral fuels of 24.9% and of oils, seeds and grains of 72.2%, the exports of cereals decreases by 24.7%, of iron and steel by 67.3% and related products by 16.1%, of electrical machinery by 17.8%, of mechanical appliances by 41.7% and of ores, slang and ash by 55.2%. As shown in figure 1, the exports of the two countries and of Russia through Ukraine are considerable in quantity, in terms of the number of destination countries and also in terms of their economic amount. The principal destinations of mineral products and metals are Europe and Asia, which together reach more than 70 percent of exports. Europe holds a high percentage for mineral products and Asia for metals. In Asia the main importing country is China because these commodities are necessary to supply its industrial sector. Instead, the main importers of cereals are Asia and Africa: about 80 percent of cereals are exported in these countries. The former requires agricultural products to provide the necessary nourishment to a very large population. For the latter it is difficult to produce cereals as the climate makes the land difficult to cultivate. In this case the comparison with the period before the war is very important because it shows the impact of the conflict on trade with individual countries. If we consider Russia, it has increase trade with China by 41%, with India by 430%, with turkey by 26% but also with european countries. There were increase in exports of 116% with Hungary and between 20 and 80 percent with Italy, Germany,

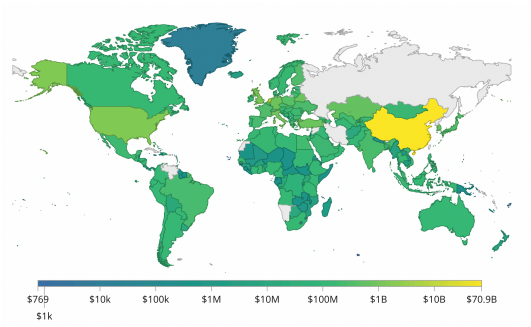
[1] www.usda.gov.

France and Greece. Instead trade recorded a negative sign with the United Kingdom 74.2%, and between 40 and 50 percent with Netherlands, United States and Finland. The increase in trade with the EU can probably be explained by the fact that in 2022 the sanctions had just been imposed and therefore had not yet limited trade. Futhermore, it should not be overlooked that Eurpoean economies are very dependent on Russia for minerals and fuels for the functioning of their industrial apparatus and in the short term it is not possible to replace them unless production is interrupted. If we consider Ukraine, we can see how exports decreased to a greater extent during the war than in Russia. This is probably because both land and sea communication routes have seen their functioning limited due to the war. In fact, if we exclude some countries territorially close to Ukraine - such as Poland, Romania, Hungary and Slovakia - which recorded an increase in imports of around 50%, all other countries, even European ones, show decreases of between 10% and 50%, China and India around 70% as weel as African and Central American countries, which mainly import cereals. From this brief examination, it can be seen that Russia and Ukraine are among the main exporters of both agricultural and mineral commodities, and this is the reason behind our analysis. Given the importance of these two countries for world exports, we investigate whether and for which commodities the war altered market rules and prices and whether and how the latter had effects on the stock markets of the G7 countries.

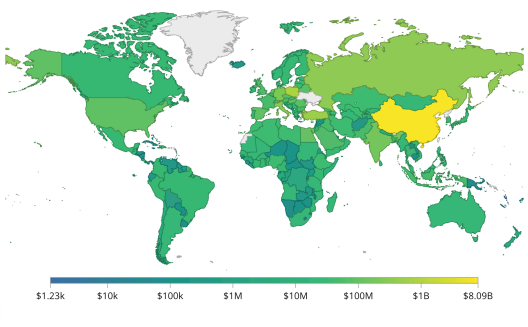
It is for all these reasons that the war between Russia and Ukraine has disrupted international trade

Figure 1: Russia and Ukraine exports countries

(a) Russia



(b) Ukraine



Source: www.oec.world/en.

and commodities markets, particularly in Europe given the geographical proximity and the numerous trade exchange. For this reason, prices have increased significantly for all energy raw materials and for some food, among others gas and wheat. Then, the Russia-Ukraine war together with the Covid-19 and financial crisis of 2008 has caused immeasurable risks for the global economy (Zhang et al. 2023 [1]; Gaio et al., 2022 [2]; Chowdhury et al., 2021 [3]) and has also made more difficult for stock markets to recover from the effects of Covid-19 (Clancey-Shang et al., 2023 [4]). The impact of the war in Ukraine on commodities markets occurs through two main channels: the pysical impact of blockades and the destruction of production capacity, and the impact on trade and production as a result of sanctions.The

consequences of the conflict in terms of increased prices of commodities and energy sources are tangible (Estrada et al., 2022 [5]). Vice versa, the link between these aspects and the dynamics of financial markets may appear less linear and more complex. From these emerges the need, little explored in the literature, to analyze the effects that the war produced on the transmission of price between commodities and the stock indices of G7 countries and whether there are differences or similarities with previous financial and non-financial crisis. The analysis is all the more complete as it considers the American continent, the US and Canada, Asia, with Japan and Europe which is more attentive to the consequences of the conflict due the proximity and intensity of trade. Therefore knowing which commodities show a greater connection with stock markets in periods of break will help policymakers, investors and portfolio managers in their decisions. Decisions not only regarding economic policies that consider possible contagion effects between markets but also portfolio investments and hedging strategies.

2 Literature review

The economic link between commodities and financial markets has been analyzed by numerous authors. Jebabli et al., 2014 [6] analyze the transmission of shocks between food, energy and financial markets during the 2008 crisis and show how volatility spillovers increase considerably after that date. Creti et al, 2013 [7] invetsigate the links between commodity price returns and stock markets and show that correlations between markets change over time and after the financial crisis are highly volatile. Mensi et al., 2013 [8] indicate a significant correlation and transmission of volatility between commodities prices indices and S&P 500 index. Ahmed et al., 2021 [9], Boubaker et al., 2017 [10] and Malik et al., 2007 [11] analyze the relationship between stock markets and oil. The former consider the Chinese stock market, commodity markets and oil price indicating a significant one-way spillover effect from the oil market to the stock market and that the Chinese stock market is exposed to the oil market. The latter consider the BRICS stock markets highlighting a time-varying volatility in all markets and that stock indices and oil prices are directly influenced by news and their volatility and indirectly by the volatility of other prices. Finally, Malik et al., examine the volatility and transmission mechanism of oil shocks with Gulf stock markets showing how these markets receive volatility from oil market, but only for Saudi Arabia is there propagation of volatility from the stock market to the oil market. Boldanov et al. 2016 [12] analyze the correlation between the price of oil and the volatility of stock market, which is in turn distinguished between oil-importing and oil exporting countries. They indicate that the correlation between the two markets changes over time and is different depending on whether there is an importing or exporting country. Futhermore, the analyses indicate that the correlations change when considerable economic and geopolitical events occur. Hanif et al., 2024 [13] explore the connection between the stock markets of

main producing and consuming countries and different commodities shocks and show variations in how these stock markets respond to oil shocks and that when extreme conditions occur the interconnectedness of market increases. Biswas et al., 2024 [14] study how geopolitical tensions caused by war make crude oil a net receiver of shocks, from a transmitter of shocks before the war. It is the shocks transmitted by oil importers that transform it into a net receiver. However, when they consider platinum and wheat they note that both exporters and importers have suffered volatility shocks. Similarly, Malik et al., 2009 [15] estimate the variance between some US sector indices and oil prices and indicate the presence of a significant transmission of shocks and volatility between oil prices and some of the market sectors examined. Ewing et al., 2016 [16] examine the volatility of oil prices and US stock market prices by incorporating structural breaks and find that there is strong volatility propagation between the two markets. Numerous contribution extend the analysis and consider the relationship between stock markets and other commodities. For example, Bouri et al., 2017 [17], note that gold and oil are the main products imported from India and that therefore expectation on the volatility of these prices could modify the volatility of the Indian stock market. They examine the cointegration and causality between these commodities and Indian stock markets. The results indicate not only the presence of cointegration and a positive impact of gold and oil volatilities on that of stock market but also a bidirectional reverse causality between the implied volatility of gold and oil prices. Al-Yahyaee et al., 2019 [18] analyze returns and risk spillovers between commodity futures and Gulf Cooperation Council stock markets and show the existence of significant return and risk spillovers between commodity and stock markets, particularly during the onset of global financial crisis. Also, they indicate how silver, platinum and energy are net transmitters of retruns to stock markets while precious metals and oil are net transmitters of risk.

The impact of the Russian-Ukraine conflict has been the subject of study. In fact, the geopolitical crisis that emerged with the increase in commodity prices - first and foremost gas, oil and wheat - has amplified the negative effects of the pandemic on the various economies, both importers and exporters of raw aterials. This occurred more significantly after many countries, including European ones, imposed economic sanctions on Russia. In this field Burns and Prager 2024 [19] show that stock market shocks affect commodity swap markets. They indicate that stock market volatility following the pandemic affected the positions of agricultural swap traders. As volatility in the financial market intensified, index traders limited their net long positions while commercial swap traders assimilated some of this by reducing their short positions. Izzeldin et al., 2022 [20] compare the reaction of international financial markets and some commodities prices to the outbreak of the war in Ukraine with those recorded during the 2008 global financial crisis and the Covid-19 pandemic and show an immediate reaction of global stock markets to the Russia-Ukrainian war while, during the other two crisis the response of the financial markets was recorded with a certain delay. Karamti and Jeribi 2023 [21] explore the impact of the Russia-Ukrainian war and the pandemic on stock markets, suggesting that G7 financial markets are more sensitive than

others to changes in commodity prices during periods of market stress. Specifically, the conflict, through the prices of raw materials - gas and wheat - had a greater influence on these markets. Lei et al., 2023 [22] consider the volatility of Karachi Stock Exchange and crude oil during crisis periods and demonstrate how after the pandemic and conflict thare has been a transmission of shocks and volatility from oil to stocks markets. Also Lo et al. 2022 [23] highlight a significant drop in yields and increase in volatility during the conflict. They attribute this to the strong dependence on Russia raw materials, dependence perceived as a risk factor on financial markets. Given that the conflict has raised concerns about the stability of energy supplies from Russia, there is a large literature that analyze the conflict and the dynamics of energy prices. Inacio et al. 2023 [24] evaluate the impact of conflict on crude oil and refined product prices globally. The results indicate a significant difference between the pre and war periods suggesting a greater impact of the conflict on European diesel prices compared to US diesel. Wang et al., 2023 [25] analyze the performance of the Shanghai and S&P index and the price of oil and gold during the conflict. The conclusions indicate relative stability only for the Chinese index while other assets suffered positive shock within several days of the outbreak of war. In this way, financial assets showed an upward trend before the conflict and a downward trend afterward. Adekoya et al., 2023 [26], examine multifractality and cross-correlation between oil prices and major stock markets and find multifractal behavior in oil and stock markets with a greater direct effect on oil persistence and European stock markets. Analyzing cross-correlations, they find evidence to support a greater effect of oil on the persistence of all stock markets during the war period. Furtermore, during the conflict the markets decreased their efficiency and the impact of oil prices is greater for the US, Japan and China whose stock markets are conditioned more indirectly by the Russia-Ukraine war and are conditioned though the oil market. Regarding the volatility dynamics of the natural gas market, Chen et al., 2023 [27] show the persistence of energy volatility that does not decrease after the crisis period of the Russia-Ukraine war.

There are also studies that have analyzed the conflict through the exploration of the economic consequences of geopolitical risk, showing how this has significant impacts on business and financial markets with particular emphasis on stock returns and volatility (Rigobon et al., 2005 [28] and Choi, 2022 [29]). Russia's invasion of Ukraine in 2022 has significantly increased geopolitical threats. The Russia-Ukraine conflict has been investigated from numerous aspects such as connections of financial markets, efficiency and risk (Boubaker et al., 2022[30]; Umar et al. 2022 [31] and Qureshi et al., 2022 [32]), and the effect on stock returns (Boungou et al., 2022 [33]). More attention was given to the analysis of the global merket reaction after a conflict (Sun et al., 2022 [34]; Khalfaoui et al., 2023 [35]; Chortane et al., 2022 [36] and Yousaf et al. 2022 [37]). Ahmed et al., 2023 [38], show that European stock markets reacted negatively to this crisis and experienced a significative abnormal return even in the period following the event. Focusing attention on NATO countries, Wu et al., 2023 [39] study the impact of the conflict on stock volatility and show how it increases after Russia's invasion of Ukraine. Furthermore, they highlight how

NATO countries have constantly played the role of risk transmitter and these regions are more sensitive to changes in the war situation unlike other countries who are more worried about the potential derivative effects of the conflict.

3 Methodology

In this paper, we use diagonal BEKK-GARCH model proposed by Engle and Kroner, 1995 [40], to estimate the conditional variance-covariance matrix. The underlying stochastic process the dyagonal BEKK model allows the QMLE of the parameters to be established as a consistent and asymptotically normal, so that the standard statistical inference for hypothesis testing is valid (Hsu et al., 2021 [41]; Katsiampa et al. 2022 [42]; McAleer, 2019 [43]). The diagonal BEKK(1,1) model, when $p = q = 1$ is thus specified below:

$$H_t = CC' + A\epsilon_{t-1}\epsilon_{t-1'}A' + BH_{t-1}B' \tag{1}$$

where R_t is the returns matrix for the commodity index and stock markets, a is a 2×1 constant vector, and ϵ_t is a 2×1 residual vector with a normal distribution and a mean of zero. H_t is the matrix of conditional variance-covariance and by definition is positive. The constant C_{ij}, is a part of the 2×2 lower triangular vector C, which is also a constant matrix. A is a residual 2×2 parameter matrix that includes a_{ij} to capture the ARCH effect in the residual in markets i and j. B is a 2×2 conditional variance matrix where b_{ij} stands for the relationship between the conditional variance between markets i and j. Then, the diagonal elements of matrices A and B capture the impact of past shocks and past volatility of the asset. On the other hand, a_{ij} and b_{ij}, where $i \neq j$, capture the cross-market effects of shocks and volatility, Li and Majerowska (2008) [44]. These cross-markets effects are shock transmission effects and volatility spillover effects. We utilize the Wald Test to test the null hypothesis that the difference between A and B equals zero in order to evaluate the volatility spillover effect. The Wald test postulates that:

$$A(i, j) = B(i, j) = 0 \tag{2}$$

for markets i and j. In order to understand the relationship between commodity markets and financial variables and to establish the existence of causality (from commodities to financial markets), after having ascertained the existence of a cointegration relationship with the Johansen and Juselius [47] test, we perform the Vector Error Correction Model to examine a long and short-term dynamic relationship. After building and within the VECM, Granger-causality [48] test are performed to indicate the direction of volatility. In the context of the analysis carried out, commodity markets Granger-cause financial indices if financial indices can be better predicted using historical values of both commodity and stock

market indices, rather than using only the historical values of the stock markets. Or, put another way, stock market indices Granger-cause the real variables if commodity indices can be better predicted using historical values of both commodity and stock market indices, rather than using only historical commodity values. With the Johansen test the null hypothesis of the lack of cointegration between commodities and financial variables is verified, compared to the alternative hypothesis of cointegration through the likelihood ratio test and the test based on the trace. The statistics are:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} (ln1 - \lambda_i) \tag{3}$$

$$\lambda_{max}(r, r+1) = -T(ln1 - \lambda_i) \tag{4}$$

whereλ_i is the $n-r$ least squared canonical correlations and T is the sample size. The trace test the null hypotesis of r cointegrating vectors against the alternative of n cointegrating vectors and the maximum eigenvalue test the null hypothesis of r cointegrating vectors aginst the alternative hypothesis of $r+1$ cointegrating vectors. Let $Y_{t,i} \equiv (X_i, M_j)$, where X_i is financial market index and M_j is the vector of commoditiy prices. If $Y_{t,y}$is cointegrated, a VEC model is:

$$\Delta y_t = \nu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \epsilon_t \tag{5}$$

where Δ is the differencing operator; $\Pi = \alpha\beta^{\iota}$ where α and β are $k \times r$ matrices; and Φ_i^* is a $k \times k$ matrix. Through the Granger-causality test we test if commodities variables spreads to financial ones. Granger test is explained as follows:

$$Y_{1t} = \phi_0^{(1)} + \sum_{k=1}^{m} \phi_{1k}^{(1)} Y_{1t-k} + \sum_{k=1}^{m} \phi_{2k}^{(1)} y_{2t-k} + \epsilon_{1t} \tag{6}$$

$$Y_{2t} = \phi_0^{(2)} + \sum_{k=1}^{m} \phi_{1k}^{(2)} Y_{1t-k} + \sum_{k=1}^{m} \phi_{2k}^{(2)} y_{2t-k} + \epsilon_{2t} \tag{7}$$

where Y_{1t} and Y_{2t}, respectively, represents financial and commodity variables. Variable y_1 granger cause y_2 if the past values of y_1 have predictive power for the current value of y_2, conditional on the past returns of y_2. The null hypotheses of no Granger causality from y_1 to y_2 involve testing the joint significance of $\phi_{1k}^{(2)}(k = 1, ..., m)$ by means of Wald test.

4 Empirical results

In the analysis we examine the prices of the main commodities exported by Russia and Ukraine and the stock market indices of the G7 countries. In the analysis, the values of the S&P indices are used as reliable references for the market trend of the relevant commodities. We use this indices because Russia and

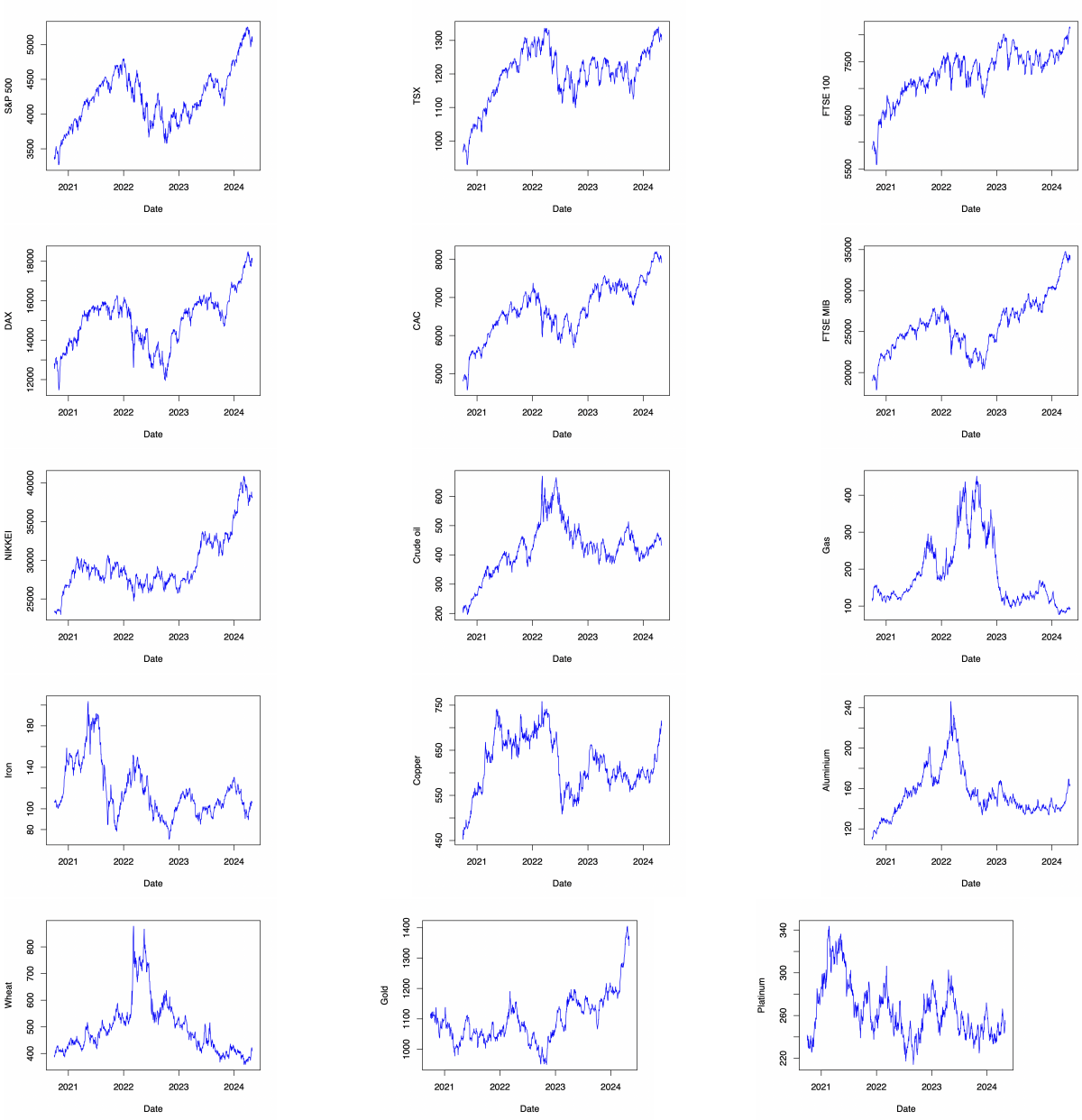
Ukraine are among the main commodities exporting countries and as seen above, exports are numerous and range from energy raw materials, to precious metals up to agricultural products. However, following the pandemic and the conflict the demand for commodities increased do to the resulting economic revival. In particular, we consider the daily returns of US (S&P 500), Canada (TSX), UK (FTSE), Germany (DAX), France (CAC), Italy (MIB) and Japan (Nikkei), the G7 countries. Among commodities we consider Crude oil, Gas, Iron, Copper, Aluminium, Wheat, Gold and Platinum. Data are collected by Refinitiv Eikon. The daily returns are calculated as follows:

$$R_t = ln(\frac{P_t}{P_{t-1}}) \times 100 \tag{8}$$

where R_t is the daily returns of the analyzed indices and P_t is the prices at time t.

The sample period - January 3, 2021, to April 30, 2024 - was marked by some events such as the Russia-Ukraine war which were able to have an impact on the markets. In fact, the conflict between Russia and Ukraine rised the price of commodities. In particular, although the prices of all the commodities analyzed began their growth at the end of 2021, not all of them showed the same trend. Figure 2 show the performance of stock market indices and commodities in the analyzed period. After the conflict, the indices fell by more than 10%, reaching their minimus between September and October 2022. Conversely, commodities continued on their growth path reaching maximum values in the days immediately following the conflict with an increase of over 100% compared to the previous period and although showing a decline at the end of 2022, they continue to show a very high values. In 2022, after the conflict, the European indices fell more than others. This can be probably be explained by the fact that European countries are the most affected by the conflict, given the high value of trade with Russia and Ukraine. In more detail, the prices of oil, gas, aluminium, copper and wheat recorded their maximum between February and March 2022, when war began, and then declined and settled back to previous levels during the course of the same year. Among these commodities, gas aluminium and wheat are those that recorded the greatest price peaks: between the end of 2021 and April 2022 gas increased by more than 200%, wheat and aluminium by more than 110%. Copper began to grow as early as 2021 and mantained these values for much of 2022 before starting to grow again at the end of 2023. Iron and Platinum show a different but similar trend. In fact, these commodities reached their maximum in 2021 and then showed various peaks between February and April 2022 and in 2023 which however much lower than values reached in 2021. The American and European stock markets show similar trends with growing values until the beginning of 2022, which overall is very volatile, and at the end of the year show a slight decline, more marked for European indices. The growth trend begins in 2023 and continues until the end of the analyzed period. The Asian market, after the growth phase at the beginning of 2021, shows a stable values throughout 2022 and at the beginning of 2023 a growth phase begins again. The two belligerents

Figure 2: Stock indices and commodity prices



are the main exporters of many energy commodities, including gas which supplies Europe from Russia through Ukraine, and agriultural commodities, both countries are among the main exporters of wheat in the world. For these reasons, we split the sample in two periods: pre-conflict period - spanning from January 3, 2021, to February 24, 2022 - and conflict period - spanning from February 25, 2022 (when Russia invaded Ukraine) to April 30, 2024.

Table 1: Descriptive statistics

Pre-conflict period

	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI	Oil	Gas	Iron	Aluminium	Copper	Wheat	Gold	Platinum
Min	-3.5925	-25360	-39554	-6.1658	-4.3905	-4.7450	-4.0667	-13.9980	-12.2112	-13.0562	-5.3258	-4.4578	-4.3500	-5.0564	-7.8760
Median	0.1164	0.1217	0.0710	0.0892	0.1607	0.1570	0.0011	0.3245	0.4581	0.2799	0.0855	0.0521	0.0399	0.0672	0.1347
Mean	0.0692	0.0746	0.0586	0.0263	0.0871	0.0765	0.0293	0.2345	0.1694	0.0490	0.1897	0.1120	0.1369	0.0045	0.0442
Max	2.4055	1.7556	4.5686	4.3167	7.2953	5.2866	3.0697	8.2777	14.6550	13.7766	3.9555	4.1104	5.8574	2.6818	5.5604
Skewness	-0.4174	-0.4724	-0.2053	-0.9068	0.1374	-0.4365	-0.2081	-0.9654	-0.2415	-0.0868	-0.3209	-0.2967	0.3137	-1.0625	-0.0726
Kurtosis	0.7251	1.2564	3.6672	4.7742	7.2066	3.1360	0.4318	5.2831	1.6368	2.1479	0.8183	0.5975	0.1271	4.2494	0.5169
JB test	17.229***	34.774***	191.79***	369.33***	735.71***	149.29***	4.9565*	448.17***	40.663***	64.958***	15.096***	9.8912**	5.877*	320.05***	3.855
ADF test	-7.8633*	-7.1619*	-6.5612*	-7.0509*	-6.6841*	-6.828*	-6.7743*	-7.1104*	-7.2652*	-6.0579*	-6.7883	-6.9395*	-5.7657*	-6.8457*	-7.306*
KPSS test	0.3404	0.1804	0.1658	0.3339	0.3207	0.3158	0.4129	0.0848	0.0596	0.1813	0.0608	0.2306	0.0723	0.1324	0.1571

Conflict period

	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI	Oil	Gas	Iron	Aluminium	Copper	Wheat	Gold	Platinum
Min	-4.4199	-3.0213	-3.9074	-6.6837	-5.0928	-6.4384	-3.0537	-13.6448	-18.2683	-10.0212	-6.9361	-4.8627	-10.0158	-2.8476	-6.0800
Median	-0.0041	0.0544	0.0667	0.0937	0.0640	0.1240	0.1020	0.1292	-0.0340	0.0570	-0.0340	0.0016	-0.1939	0.0177	-0.0296
Mean	0.0293	0.0063	0.0218	0.0473	0.0354	0.0557	0.0706	-0.0271	-0.1547	-0.0340	-0.0511	0.0010	-0.0800	0.0326	-0.0207
Max	5.3952	3.2339	3.8391	4.4719	6.8827	6.7143	3.8604	8.2623	13.3517	8.0497	6.0896	6.8814	8.2831	3.0932	5.6252
Skewness	-0.1576	-0.1316	-0.3134	-0.4768	0.1455	-0.4699	-0.0054	-0.4541	-0.3365	-0.3100	0.1120	0.0100	0.1647	0.0481	0.1074
Kurtosis	1,7474	1.1127	3.1465	4.1379	4.3723	4.0999	0.2669	1.9942	0.9128	1.1861	1.8005	1.9586	1.4247	1.0065	-0.0084
JB test	69.727***	28.735	228.91***	401.74***	427.56***	394.16***	1.468	106.72***	28.406***	39.615***	72.804***	84.888***	47.181***	22.386***	1.054
ADF test	-7.3551*	-7.4466*	-7.881*	-7.362*	-7.4853*	-7.26*	-8.3195	-9.784*	-7.7209*	-8.5447*	-9.0638*	-7.3066*	-8.9888*	-7.7193*	-9.0125*
KPSS test	0.1705	0.0911	0.0395	0.0968	0.0615	0.1685	0.0653	0.0431	0.1530	0.0866	0.3824	0.2985	0.0434	0.2218	0.0424

Note: *, **, *** indicate significance at 10%, 5%, 1% respectively.

Table 1 present the descriptive statistics for stock markets and commodities for all two periods. If we examine the difference between max and min we note that the greatest gap is recorded in Conflict period when all markets underwent large increase which they recovered during the year and the following. For the pre-Conflict period all series shows a positive and close to zero mean. During the Conflict period the mean of all financial indices is positive but commodities, except copper and gold, have negative values. This consideration indicates how the conflict event affected the financial and commodities market differently. The skewness shows negative values for all indices, except CAC and wheat, in pre-Conflict period. Conversely, during the war some indices showed positive value and others negative - CAC, Aluminium, Copper, Wheat, Gold and Platinum. In any case all values are close to zero, indicating a greater level of skewness. Also for kurtosis in the pre-Conflict and Conflict periods, all indices show positive values except Platinum in Conflict period. All values are higher, even if slightly, in pre-Conflict period except for some commodities but all variables have values around 3 or slightly higher, acceptable level of kurtosis. This indicates that the series during the war period approximate a normal distribution. The Jarque-Bera test [49] confirms that the distribution of returns is not asymptotic. The results of the Augmented Dickey-Fuller test [50]for the presence of a unit root and the KPSS test [51]for stationarity confirm that all returns are stationary for all the periods considered.

Table 2: BEKK estimates

	Pre-Conflict period							Conflict period						
	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI
Panel A: Oil														
μ_1	0.3094**	0.3093**	0.3260**	0.2914*	0.3110**	0.2627*	0.3255**	0.0038	0.0117	0.0179	0.0141	-0.0796	-0.0052	-0.0282
μ_2	0.0864*	0.0833*	0.0644	0.0559	0.0761	0.0900	0.0285	0.0343	0.0420	0.0330	0.0610	0.0265	0.1173**	0.0651
c_{11}	2.1140***	1.2827	0.4938	2.0298***	1.9543***	2.0100	0.5706	0.5034	2.4343	0.5034	2.3413***	2.4241***	0.5034**	2.3933***
c_{12}	0.0133	0.0411	0.0426	0.0902	0.1120	0.1684	0.0205	0.0177	0.0161	0.0414	0.0563	0.0461	0.0006	0.0187
c_{22}	0.1845	0.3064**	0.6042***	0.2247	0.2107	0.2241	1.0776***	0.2324***	0.1677	0.1678	0.2242	0.2201	0.2474**	0.3700
a_{11}	0.0001	0.009	0.0001	0.0006	0.0118	0.1829*	0.2970***	0.0677	0.2169*	0.2382**	0.1213	0.0100	0.0660	0.0046
a_{22}	0.3784***	0.3696***	0.0010	0.4754***	0.3271	0.0002	0.3290***	0.0898	0.4056***	0.2591	0.2974	0.0280	0.3860***	0.1009
b_{11}	0.0494	0.7664*	0.9991***	0.2429	0.2830	0.0001	0.8565***	0.9115	0.0001	0.9505***	0.0001	0.0001	0.9520***	0.0001
b_{22}	0.8563	0.7527***	0.5539***	0.8245***	0.8395***	0.0007	0.0005	0.8894***	0.8226	0.9086***	0.9107	0.8026***	0.8642***	0.8376***
Panel B: Gas														
μ_1	0.2144	0.2591	0.2255	0.3050*	0.2239	0.3011*	0.1693	-0.1207	0.0320	-0.1547	-0.1421	-0.1413	-0.0798	-0.1547
μ_2	0.0735*	0.0791*	0.0438	0.0302	0.0761	0.0777	0.0293	0.0680	0.0430	0.0218	0.0933**	0.0634	0.1137*	0.0706
c_{11}	1.4190***	3.0806***	0.7379	0.7379**	3.1065***	3.0385***	3.6899	4.1499	0.8759**	4.3799	4.1833	2.2861	4.2801***	4.3799
c_{12}	0.0197	0.0142	0.0025	0.0138	0.0303	0.0027	-0.0333	0.0259	0.0210	-0.0007	0.0139	0.0559	0.0137	-0.0099
c_{22}	0.3207**	0.3875***	0.8870***	0.2248	0.2142	0.3582***	1.1493	0.2311**	0.2167***	0.8419***	0.2240***	0.2198***	0.2470	1.1255***
a_{11}	0.4393***	0.5685***	0.3723*	0.3541***	0.5773***	0.6049***	0.1504*	0.2503**	0.1221*	0.1003**	0.2191	0.0016	0.0001	0.1309*
a_{22}	0.3938***	0.4029***	0.1907	0.3031	0.3479**	0.3508***	0.1000	0.3126***	0.3058***	0.1000	0.3669***	0.3173***	0.4324***	0.1000
b_{11}	0.7956***	0.0001	0.9050***	0.9159***	0.0001	0.0001	0.9000	0.0001	0.9509***	0.9000	0.0001	0.8443***	0.0100	0.9000
b_{22}	0.8063***	0.6067*	0.1340	0.9178	0.8287***	0.8854***	0.9700***	0.9277***	0.8942***	0.9052***	0.8948***	0.9164***	0.8487***	0.9508***
Panel C: Iron														
μ_1	0.0490	0.0490	0.1880	0.0490	0.0490	0.0490	0.0490	0.0109	0.0439	0.0695	0.0142	0.0417	0.0094	-0.0340
μ_2	0.0692	0.0746	0.0555	0.0263	0.0870	0.0765	0.0293	0.0662	0.0314	0.0608*	0.0623	0.0686*	0.1192**	0.0706
c_{11}	3.1293	3.1293	0.6702	3.1293	3.1293	3.1294	3.1291	0.4799	0.4799*	2.2416***	1.8776***	2.1853***	0.6322	2.3999***
c_{12}	-0.0121	-0.0099	0.0150	-0.0819	-0.0572	-0.0509	-0.0985	0.0766*	0.0634	0.0181	0.0415	0.0325	0.0284	-0.0085
c_{22}	0.9249	0.6929***	0.8621	1.1235	1.0699	1.1380	1.1455	0.2271	0.1664*	0.1681	0.2243*	0.2178	0.4551***	1.1255***
a_{11}	0.1001*	0.1011*	0.5270***	0.1050*	0.1400*	0.15551*	0.1061*	0.1408	0.1836***	0.3114***	0.2898***	0.3205***	0.0001	0.1000
a_{22}	0.0110	0.1004	0.1801*	0.1008	0.1020	0.1774	0.1076	0.3007	0.0001	0.3551***	0.3631**	0.3386***	0.4697***	0.1001*
b_{11}	0.9001	0.9006	0.8165***	0.9000	0.9510	0.9090	0.9000	0.8955	0.8995***	0.0019	0.5290*	0.0001	0.9415***	0.9092***
b_{22}	0.9099***	0.9009***	0.2869	0.9100***	0.9001***	0.9068***	0.9100***	0.9421	0.9802***	0.8443***	0.9103***	0.8932***	0.7540***	0.9008***

Continue

Panel D: Aluminium

μ_1	0.1897	0.1855*	0.2010**	0.1897	0.2436***	0.1897	0.1898	-0.0370	0.0131	-0.0511	-0.0037	-0.0045	-0.0659	-0.0531
μ_2	0.0692	0.0830*	0.0583	0.0263	0.1040*	0.0765	0.0293	0.052860.0320	0.0218	0.0495	0.0535	0.1041*	0.0492	
c_{11}	1.4267	1.3783***	1.3380	1.4267	0.2853	1.4267	1.4267	0.3213**	0.3213*	1.6066***	0.3213**	0.3213	1.1272***	1.4628***
c_{12}	-0.0114	0.0149	0.0393	-0.1082	0.0059	-0.0347	-0.0801	0.0687	0.0318	-0.0299	0.0435	0.0368	0.0139	0.0139
c_{22}	0.9249	0.1378	0.8361***	1.1213	0.9420***	1.1386	1.1469	0.2303**	0.2747*	0.8414***	0.2214	0.2196	0.2470*	0.3112
a_{11}	0.1057*	0.0001	0.0010	0.1000*	0.0010	0.1380*	0.1095*	0.0001	0.2997***	0.1001*	0.0019	0.1912	0.2454***	0.2370***
a_{22}	0.1006	0.4781***	0.0248	0.0011	0.2012*	0.1006	0.1405	0.0670	0.2700**	0.1000	0.0001	0.3136	0.6584***	0.1060
b_{11}	0.9010***	0.0010	0.0001	0.9005***	0.9030***	0.9076***	0.9503***	0.8154***	0.9291***	0.9011***	0.8945***	0.9623*	0.5051***	0.0001
b_{22}	0.9510***	0.4307	0.0994	0.9100***	0.0001	0.9007***	0.9078***	0.9366***	0.8948***	0.9077***	0.9460***	0.8974	0.4397***	0.9083

Panel E: Copper

μ_1	0.0893	0.0921	0.0593	0.1120	0.1795*	0.1254	0.0755	-0.0046	0.0100	-0.0100	0.0100	0.0101	-0.0100	0.0100
μ_2	0.0639	0.0807*	0.0462	0.0026	0.1072*	0.0733	0.0401	0.0678*	0.0079	0.0420	0.0734*	0.0680	0.1043*	0.0633
c_{11}	0.4642	1.3665***	1.3199***	1.4299	1.1335*	1.0075***	1.0590***	1.2680***	0.6256***	1.2393***	1.1434***	1.1042***	1.1862***	0.3021
c_{12}	0.0063	0.0447	0.0251	-0.0005	0.0773	0.0172	0.0466	0.2460	0.0463	0.0081	0.0334	0.2476***	0.2954***	0.0040
c_{22}	0.2088	0.1374	0.1809	1.1265	0.2136	0.2271	0.3453	0.2282	0.1628	0.2284***	0.2219*	0.5164**	0.2415	1.1010***
a_{11}	0.1015	0.0953	0.2948**	0.1570*	0.0786	0.2312*	0.2631**	0.1013	0.2653***	0.0088	0.1407*	0.3039***	0.0058	0.2485
a_{22}	0.3737	0.4972***	0.3401***	0.1000	0.4426***	0.3912***	0.4048***	0.3848	0.3818***	0.3785***	0.3092***	0.6398***	0.6580***	0.1299
b_{11}	0.9383	0.0002	0.0662	0.9070***	0.5724	0.6447**	0.4199*	0.0110	0.8323***	0.0001	0.0030	0.0001	0.0001	0.8896***
b_{22}	0.8900	0.5655***	0.7743***	0.9003***	0.8491***	0.8950***	0.6416***	0.8948	0.7065***	0.8332***	0.9123***	0.0026	0.6063	0.0001

Panel F: Wheat

μ_1	0.1369	0.1369	0.1405	0.1370	0.1987*	0.1363	0.1370	-0.0800	-0.1163	-0.0800	-0.0801	-0.0806	-0.0806	-0.0800
μ_2	0.0692	0.0746	0.0583	0.0263	0.1081*	0.0765	0.0293	0.0293	0.0210	0.0218	0.0472	0.0354	0.0557	0.0706
c_{11}	1.8150***	1.8150	1.6147***	1.8150	0.6537	1.8150	2.4636***	0.4927	2.4636	2.4636	2.4636	2.4636***	2.4637***	
c_{12}	-0.0560	-0.0248	0.0157	-0.1160	0.0184	-0.0063	-0.0719	-0.0081	0.0096	-0.0944	-0.1472	-0.1002	-0.0837	-0.0627
c_{22}	0.9233***	0.6926	0.1826	1.1205	0.3941***	1.1391	1.1475	1.1631***	0.2463**	0.8366	1.1126	1.0968	1.2342***	1.1238***
a_{11}	0.1056*	0.1053*	0.2156*	0.1057*	0.1451*	0.1206*	0.1000*	0.1011*	0.2996***	0.1479*	0.1431*	0.1361*	0.1121	0.1000
a_{22}	0.1071	0.1000	0.0001*	0.1000	0.4729***	1.095	0.1200	0.1101*	0.2816***	0.1001	0.1564*	0.1604	0.1149	0.1565*
b_{11}	0.9020***	0.9100	0.2042	0.9021***	0.9191***	0.9130***	0.9011***	0.9501***	0.8843***	0.9000	0.9000	0.9012	0.9572***	0.9592***
b_{22}	0.9008***	0.9000***	0.7131**	0.9082***	0.8188***	0.9007***	0.9008***	0.9203***	0.9112***	0.9051***	0.9931***	0.9350***	0.9189***	0.9161***

Panel G: Gold

μ_1	0.0104	0.0042	-0.0021	0.1115	0.0045	0.0045	-0.0046	0.0328	0.0390	0.0326	0.0412	0.0326	0.0327	0.0075
μ_2	0.0771*	0.0654*	0.0404	0.0200	0.0870	0.0765	0.0206	0.0619	0.0247	0.0218	0.0602*	0.0354	0.0557	0.0899*
c_{11}	0.9445	0.3064	0.5377***	0.7253***	0.9739	0.9739	0.5869**	0.7739***	0.4329***	0.9002	0.2969**	0.9003	0.9006	0.1800
c_{12}	0.0585	0.0408	0.0072	0.0002	-0.0786	-0.1014	0.0141	0.0207	0.0202	-0.0295	0.0082	-0.0318	-0.0409	0.0008
c_{22}	0.1847	0.3558***	0.1826	0.7938	1.0685	1.1346	1.0483***	0.2317*	0.2028	0.8114	0.2244***	1.1009	1.2364	1.0975***
a_{11}	0.0001	0.0415	0.1045*	0.0001	0.1050*	0.1807*	0.1399*	0.0001	0.1977**	0.1478*	0.0001	0.1493*	0.1492*	0.1468*
a_{22}	0.3860***	0.4450***	0.2163***	0.6709***	0.1067	0.1000	0.3027***	0.2958**	0.3719***	0.1568*	0.3681***	0.1607	0.1599*	0.0765
b_{11}	0.1799	0.8782***	0.6609***	0.1804	0.9008***	0.9088***	0.4867	0.1343	0.8540***	0.9755***	0.9081***	0.9067***	0.9650***	0.9554***
b_{22}	0.8681***	0.7304***	0.7711***	0.0594	0.9070***	0.9007***	0.0019	0.9262***	0.8653***	0.9615***	0.9012***	0.9060***	0.9603***	0.0001

Continue

Panel H: Platinum

μ_1	-0.0009	0.0256	0.0420	0.1502	0.0675	0.1737*	0.0267	0.0353	-0.0055	-0.0458	0.0056	-0.0170	0.0031	-0.0207
μ_2	0.0695	0.0684*	0.0430	0.0761	0.0815	0.1057*	0.0590	0.0762*	0.0225	0.0607*	0.0756*	0.0629	0.1209**	0.0707
c_{11}	1.2604**	1.9013***	1.7462***	1.9182***	1.7280	1.6103	1.7982***	1.7323***	1.7482***	1.7990***	1.7966***	1.6679***	1.5850***	1.8244
c_{12}	0.0956	0.0137	0.2368*	0.0170	0.1919	0.0184	0.0938	0.1255	0.1124	0.0799	0.0476	0.1985	0.1453	-0.0377
c_{22}	0.2447*	0.1379	0.1775	0.2246	0.2114	0.2270	0.2293	0.2257*	0.1628*	0.1677	0.2243***	0.2173	0.2931*	1.1249
a_{11}	0.1634*	0.0001	0.2489*	0.0001	0.2905***	0.0001	0.2389**	0.2728**	0.0594	0.1287	0.0766	0.2165	0.2402**	0.1440*
a_{22}	0.3321***	0.4467***	0.2909**	0.4432***	0.0001	0.3698***	0.3423***	0.3403***	0.1959***	0.4449***	0.4018***	0.3963***	0.4289***	0.1052*
b_{11}	0.7242***	0.0010	0.3049	0.0100	0.0064	0.5509	0.0923	0.0001	0.0180	0.0001	0.1063	0.3148	0.4259*	0.9110***
b_{22}	0.9018***	0.6062**	0.9053***	0.7767***	0.0101	0.8546***	0.2090	0.9282***	0.8882***	0.8055***	0.8825***	0.8737***	0.8498***	0.9630***

Note: *, **, *** indicate significance at 10%, 5%, 1% respectively.

In this section we analyze the estimation of pair-wise of models employing the BEKK framework. The pairs are made up of each commodity compared to each market indices of the G7 countries. The indices of the economies belonging to the G7 were considered in the analysis because they are countries similar to each other in terms of development, but at the same time different in terms of the degree of trade with Russia and Ukraine. Then, if on the one hand this makes the analyses robust and comparable, on the other it allows us to grasp the differences and trace them, at last in part, to the greater or lesser interconnection with the two belligerents. Futhermore, it gives us a more complete picture of the effects of the war on the markets of heterogeneous countries variously linked to Russia and Ukraine. Table 2 reported the estimation results for each pair and for all periods. The coefficients μ_1 and μ_2 represent the constant term of the mean equation, instead c_{11}, c_{12} and c_{22} are the constant term of variance equation. It is explained in more detail the diagonal parameters in matrix A that capture the ARCH effects, the own shock, a_{11} and a_{22} and the diagonal parameters in matrix B that capture the GARCH effects, own volatility spillovers, b_{11} and b_{22}. Whereas the results of the coefficients estimates a_{ii} and b_{ii}, at the 1% level are statistically significant in many cases it is possible to state that current volatility is significantly influenced by one's past quadratic shocks and one's past volatility. Furthermore, the fact that for all the pairs considered, $|a_{ii}| < |b_{ii}|$ indicates that current conditional variances are influenced more by the size of previous conditional variances rather than by the size of previous innovations. Therefore, the considerations made regarding the fact that past volatility coefficients are higher than past shock coefficents allow us to state that previous volatility are more significant predictor of current volatilities than past own shocks, and this for all sample periods. Thus, the results show that lagged shocks and volatility significantly and positively influence the current conditional volatility of commodities and stock returns in most countries analyzed during two periods. In particular, during conflict period, the spillover effects of the shocks themselves are positive and significant in stock returns of all countries. Then, the results suggest that past shocks inversely influence the current volatility of stock returns in periods when external events disrupt financial markets.

After the BEKK estimates, in order to verify the presence of cointegration between variables, the Augmented Dickey-Fuller Unit Root Test [52] is carried out to ascertain the non-stationarity condition of variables themselves. In the study the ADF test is conducted for all aggregates, both referring to financial and commodity markets, taking into consideration the lag lenghts and possible deterministic components. The ADF estimation results, not reported, show the presence of unit roots in first difference, than there is possible long-run linear combination. The presence of cointegration occurs when multiple time series move together in a similar way in the long term, so much so that they appear to have the same trend. Then, cointegration involve the existence of the long-term relationships between two or more variables and studies their evolution around equilibrium. Consequently, al least one variable can be used to predict the others because there is a valid causal relationship based on the Error Correction

Table 3: Summary VECM

	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI
Pre-conflict period							
ECT(-1)	-0.0244**	-0.0232*	-0.0529***	-0.0474***	-0.0261**	-0.0249**	0.0031
R-Squared	0.0126	0.0081	0.0306	0.0283	0.0123	0.0112	0.0009
Durbin-Watson	2.0001	1.9904	1.9448	2.0537	1.8980	1.9389	2.0963
Conflict period							
ECT(-1)	-0.0253**	-0.0742***	-0036	-0.0570*	-0.0523**	-0.0064**	-0.0541***
R-Squared	0.0143	0.0925	0.0242	0.1088	0.0716	0.0152	0.1126
Durbin-Watson	2.0119	2.0445	1.9829	1.9681	1.9616	1.9853	1.9649

Note: *, **, *** indicate significance at 10%, 5%, 1% respectively.

Model. Given that variables follow unit-root processes and are cointegrated, we estimate the Vector Error Correction Model to examine the effects of changes in commodity prices on financial markets, in order to verify their adjustement mechanism. Table 3 report the final estimated findings.

Fisrt of all we note that numerous error-corrections, except for Nikkei in the Pre-conflict anf FTSE in conflict period, are statistically significant at 1% level and show a correct negative sign. The size are different between the two periods, greater in the Conflict period when the size is between -0.0036 and -0.0742 and this suggests that the 0.0036% (0.0742%) of disequilibruim during the period $t-1$ is corrected in day t. Then, the significantly negative error correction term representing the negative feedback necessary in financial index to bring the commodity prices back to equilibrium. The goodness of fit of statistical model is well performed as shown by the R-squared and Durbin-Watson test. The short-run Granger causality test, table 4 indicate the direction of causality between variables, based on the VECM estimate. The results specifie that in pre-Conflict period there is a short-run causal effect running form oil to Canadian stock market, Aluminium to UK, copper to UK and German stock markets and gold to US and German markets. On the other hand financial markets Granger-cause commodity markets limited to oil, copper, wheat and gold. Instead, in conflict period we note a short-run causal effect running from oil to European financial markets, gas to all financial markets except TSX, aluminium to TSX, CAC, MIB and Nikkei, copper to TSX and MIB, wheat to S&P, CAC, MIB, Nikkei, gold only to S&P, DAX and Nikkei and platinum to TSX and DAX. Financial markets show the fewer relationship. Of considerable importance is the causality between gas and wheat and financial markets, Russia and Ukraine are the main exporters of these commodities. In fact, in the conflict period Granger-cause stock indices with very high values especially regarding European stock exchange. Russia, via Ukraine, is the main gas supplier to Europe which has suffered the consequences of price increases. In addition, to achieve long-tern decarbonisation objectives, the EU has assessed investments in natural gas infrastructure as

sustainable. Also wheat is important for export of Russia and Ukraine and the greatest causality is recorded with the US, French, Italian and Japaneese markets. In fact, although France and Italy are producers of cereals, their needs are greater and therefore they are also importers. Consequently, their economies are sensitive to fluctuations in the relative prices.

Table 4: Granger causality

	S&P	TSX	FTSE	DAX	CAC	MIB	NIKKEI	Oil	Gas	Iron	Aluminium	Copper	Wheat	Gold	Platinum
Pre-conflict period															
S&P		8.0609**	7.4189**	7.3808**	7.5961**	4.7415*	0.4131	1.5114	1.2269	1.2597	0.0520	3.1026*	2.5341	0.1511	0.7286
TSX	6.2391*		8.6805**	3.2671*	6.0448*	4.1215*	0.0531	2.7781*	1.5959	1.2986	0.5612	2.2829	4.6174*	0.1238	0.8894
FTSE	0.6637	3.9375*		5.2656*	0.0649	0.5737	0.3145	7.7333**	1.4684	0.2286	0.2653	3.7581*	4.0605*	0.0051	0.0611
DAX	0.3663	0.6845	0.6542		0.4825	0.4942	0.8870	0.4886	2.3216	0.6624	0.0001	2.4046	1.1365	0.5729	1.1125
CAC	2.3411	15.6970***	10.6430**	9.8592**		2.1132	0.0888	3.1052*	1.2104	0.4651	0.7452	3.2950*	2.1807	0.1630	0.5008
MIB	2.3313	13.4150***	11.1880***	14.4730***	0.0081		0.4765	3.3725*	0.9638	0.4938	0.1132	3.6657*	1.4640	0.3142	0.1165
NIKKEI	0.4335	0.0366	0.1169	3.6931*	0.3513	0.6935		0.2998	0.0297	0.0330	0.4035	1.6215	0.0225	7.6567**	0.0499
Oil	1.2358	4.8565*	1.8940	0.6565	0.4759	0.8901	0.2031		2.7213*	1.1003	0.0914	3.0480*	4.9268*	0.1151	0.1210
Gas	0.1881	0.1255	0.0398	0.5811	0.0751	0.1935	0.2897	0.0004		10.4700**	0.0248	0.0625	2.4468	0.0745	2.5462
Iron	0.0179	0.1588	0.0976	0.5530	0.0243	0.0278	0.0704	0.0137	0.6540		0.2093	0.0357	0.5617	0.0682	0.0830
Aluminium	0.1931	1.5313	3.7747*	0.0409	0.3340	0.9295	0.3358	6.0134*	5.5198*	1.1882		0.8234	6.0721*	0.0078	0.6618
Copper	0.9647	1.7939	3.6640*	6.4942*	1.9952	2.3193	0.0740	1.0048	0.6121	0.3278	1.4382		0.4596	0.6921	1.4600
Wheat	0.1006	0.0001	0.0333	0.4583	0.0176	0.0061	1.0738	0.0004	1.8028	1.2816	0.1457	0.4003		0.0039	2.0316
Gold	3.2840*	0.9347	1.5640	3.3553*	0.6619	0.9658	1.3943	0.0173	0.2519	0.2419	0.0680	2.0705	0.2700		4.7326*
Platinum	0.0077	0.4044	0.3499	1.5909	0.0045	0.0256	2.2207	0.0351	0.0935	4.6030*	1.0806	1.1531	0.0110	2.1424	
Conflict period															
S&P		0.7064	0.0536	0.7622	1.8073	1.2508	0.0323	0.4220	4.3184*	1.7939	0.0329	1.5561	1.2427	0.4971	1.7753
TSX	1.6413		0.0354	0.0030	3.0221*	3.1015*	1.5779	0.4012	1.3894	0.9623	0.3184	5.7685*	1.1004	0.0078	0.0205
FTSE	1.2763	4.2481*		12.7750***	4.0799*	1.1460	0.3171	0.1990	0.4848	3.5953*	1.6832	5.3767*	0.0734	2.9488*	2.1864
DAX	3.3765*	0.2206	1.9284		0.0198	0.2072	1.8347	0.1426	0.0382	1.9931	0.0453	1.2141	0.1788	6.6285*	0.1063
CAC	3.6536*	1.1466	2.0157	94.9950***		0.0138	2.4958	0.6967	0.0002	1.3575	0.1254	1.9255	0.6287	7.2913**	0.5809
MIB	4.8296*	0.8586	1.0818	49.0820***	0.7063		1.6964	0.1400	0.0392	2.7010	0.0241	1.4687	0.3470	10.5730**	0.1815
NIKKEI	13.3670***	0.7500	0.2304	2.3686	2.4246	6.3192*		0.8451	1.4616	1.8649	0.0623	0.2950	0.3861	0.5234	0.1920
Oil	2.3049	0.0613	2.4125	6.0186*	0.0625*	5.6411*	2.3598		10.4590**	0.0047	3.0484*	0.0299	3.5866*	1.2855	0.1291
Gas	7.2949**	1.0239	5.5756*	13.2870***	19.0460***	11.3190***	7.0248**	0.3530		0.6071	0.0020	0.3174	0.8298	4.7080*	0.5529
Iron	0.1465	2.6083	0.1272	0.3798	1.4792	2.2853	1.8042	0.7991	0.4047		0.6744	8.3162**	2.7133*	1.0535	0.0020
Aluminium	1.0712	3.3022*	0.3066	1.7760	3.9131*	4.3004*	2.9680*	2.5429	3.1513*	1.2885		0.2548	12.2730***	0.2977	0.2097
Copper	0.7792	5.2534*	0.0008	0.5577	2.6329	3.2645*	1.5662	1.7988	0.2027	1.1739	0.0174		2.7396*	0.0853	0.0861
Wheat	4.5122*	0.0557	0.7567	2.4869	3.7335*	4.1361*	6.4175*	4.8166*	1.7121	0.8229	0.0195	0.0675		3.0716*	0.1267
Gold	7.3463**	2.1414	2.2995	4.3907*	2.0305	0.6843	2.9658*	0.0051	0.1771	0.9531	0.2070	0.0039	0.0265		0.6175
Platinum	0.0764	3.9318*	1.0673	3.4991*	0.0444	0.0500	0.1343	0.3635	2.9874*	0.1171	0.4394	0.6752	0.4078	0.6256	

Note: *, **, *** indicate significance at 10%, 5%, 1% respectively.

5 Conclusion

The Russia-Ukraine conflict has altered economic dynamics and global balances. If the consequences of the war in the long term are uncertain, in the short term the prices of commodities, especially gas and wheat which the two belligerents export in large quantities, have recorded considerable increases and with regard to wheat have generated situations of food shortage. These effects recorded in the commodity markets also have had repercussions on the stock markets of the different countries. In this article we analyzes the relationship between the stock returns of G7 countries and commodity indices by distinguishing the pre-Conflict period and the Russia-Ukraine conflict. The results of the BEKK and VECM models have clear implications for hedgers in these markets. In fact, given the temporal variability between the commodity indices and the stock markets and the long-lasting nature of the propagation of volatility spillover in the war period the portfolio weights should be adjusted: a commodity indices hedge for these markets is only effective for the conflict period when tension on commodities markets has increased. Furthermore, asymmetries can lead to a reduction in the impact of the previous volatility of each index on its current volatility. This is consistent with what Chancharat S. and Sinlapates, 2023 [53] shown regarding the correlation between oil and the Asian stock markets. In practice, the results show that in periods of high volatility and instability, investors should use great caution in their choices. Indeed, stock markets present numerous risks and opportunities for investors particularly during times of crisis, and it is that underlies changes in diversification strategies. Policymakers have sought to strengthen the security of supply of raw materials to reduce dependence on import from Russia. From this perspective, the Russia-Ukraine war fueled energy security problems while, as argue Deng et al., 2023 [54], most investors were directed towards climate regulation. Then, in the long term, the way to combine the two needs is to increase the share of renewable energy. Future research could analyze how geopolitical events are able to impact commodities prices and global stock markets.

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