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ASSESSING THE IMPACT OF THE RUSSIA-UKRAINE WAR AND COVID-19 ON SELECTED EUROPEAN CURRENCIES AND KEY COMMODITIES

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Abstract. This study measures the spillover effects of the Russia-Ukraine war and the COVID-19 pandemic on currency pairs as the Russian ruble, Czech koruna, Polish zloty, Hungarian forint, Swedish krona, Bulgarian lev, Danish krone, Romanian leu, Ukrainian hryvnia, and Turkish Lira. By employing the TVP-VAR model we investigate the dynamic connectedness among these currencies and key energy and agricultural commodities. The data series encompasses two consecutive non-economic shocks – the Ukraine war and the COVID-19 pandemic – and a preceding period of general stability during 2018 and 2019. The importance of geopolitical context in shaping currency dynamics was present in countries with heavy dependence on Russian gas. The findings indicate a limited direct impact of commodity price fluctuations on the value of these currencies. At the same time, geopolitical decisions primarily related to the Russian Ruble and energy dependencies significantly impacted their valuation. The study reveals the complexity of currency dynamics and the influence of geopolitical risks and global health crises on exchange rate volatility and commodity dependencies.

Keywords: Russia-Ukraine war, COVID-19, TVP-VAR, currency dynamics, energy and agricultural commodities, FX market.

JEL Classification: F15, F31, G15.

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1. Introduction

The Russian invasion of Ukraine has sent shockwaves through the European financial system, effectively triggering a state of emergency. Since February 24, 2022, the specter of a third world war has threatened ominously. This incursion has thrust the European Union (EU) into its most intricate security dilemma since the Cold War. In times of armed conflict such as this, the repercussions are far-reaching, extending beyond geopolitical concerns to critical issues like food insecurity and supply chain problems. The Russian invasion of Ukraine again highlighted the weaknesses of the international food security network (Behnassi & El Haiba, 2022; Zhou et al., 2023). These two countries remain the leading exporters of agricultural commodities, accounting for 30% of the worldwide supply of barley and Wheat (International Grains Council [IGC], 2023). Considering other factors, agricultural commodities gave additional impetus to global inflation. Aliu et al. (2023a) argued that the sanctions from the West

have accelerated Wheat, barley, and sunflower oil prices. The inflation that exploded during the conflict in Ukraine exceeded even the peak of the 1970s, related to the oil shortages (Bouri et al., 2023). Accelerated inflation, mainly due to the restricted supply of agricultural commodities, weakened worldwide purchasing powers. Hence, Tong (2024), using a heteroscedasticity-based estimator, investigated the implications of the Russia-Ukraine war on 86 countries. The findings revealed that the consequences directly appeared in the growth potentials, inflation issues, and stock market crash. On the other hand, gas and oil prices spiked high mainly because of supply chain difficulties. Russia was under strict sanctions while other OPEC members announced production cuts (Al Jazeera, 2023a). Consequently, Bagchi and Paul (2023), using Fractionally Integrated GARCH (FIGARCH), highlight that oil prices during the war in Ukraine imposed a tremendous slump on the G7 national currencies. Another study by Sokhanvar and Lee (2023) analyzed energy prices from January 2022 to November 2023 through the 4-h time frame. Their findings show that the Australian dollar gained ground in FX compared to the Euro, the British pound, and the Japanese yen. Beyond that, the EU was highly dependent on Russian gas and oil, which was an additional concern. Due to their importance, the instability of gas and oil prices occupied written and electronic media coverage. Russian gas was essential for well-functioning industries in Germany, Austria, the Czech Republic, Poland, Slovakia, and several other EU members. The Russian gas prices were the primary source of the crash in major European equity markets (Aliu et al., 2023b). The study by Umar et al. (2022) examines the impact of geopolitical risk (GPR) from the Russian-Ukrainian conflict on global financial markets. They note that market returns demonstrate a combination of both negative and positive associations with global political risk. The banking industry constrained its activities and tightened the lending criteria. The EU banks panicked due to capital flight and possible liquidity problems. Batten et al. (2023) find that the problem differs in all countries and regions. For example, Asian banks have been more resilient and immune to the Ukraine war than European ones. Another study by Martins et al. (2023) shows that the 100 largest European listed banks with ties to the Russian economy were the most exposed. The geographical proximity to the conflict zone exposes the EU countries to absorbing the most economic costs (Liadze et al., 2022). As a result, the Euro was devalued, but at the same time, the currencies of the non-Euro area went into free fall. Since Russian President Vladimir Putin ordered the invasion of Ukraine, multinational companies were forced to reexamine their ties with Russia. Despite complicated deals, many (such as McDonald's, PepsiCo, and Shell) left the country (Washington Post, 2022). In this context, the investigation by Kiesel and Kolaric (2023) indicates positive stock returns for companies that followed the leave decision compared to those stay decisions. Russia and Ukraine play a crucial role in global food security as leading producers of Wheat and corn. The oil issue is different; OPEC member countries have a significant advantage in diversifying oil production. Fluctuations in commodity prices directly impact the exchange rates. As commodity prices rise, non-eurozone countries face increased pressure, paying more in hard currencies (such as U.S. dollars or Euros) while simultaneously experiencing strain on the value of their national currencies. In our study, we aim to identify the commodities that have played a decisive role in the devaluation of the currencies under examination.

Like other asset classes, FX markets have not escaped the shock during the Russian invasion of Ukraine. Two weeks after the war, the Deutsche Bank Currency Volatility Index lost more than 10% of its market value (Consumer News and Business Channel [CNBC], 2023). The possible Russian invasion into the EU territory triggered capital flights mainly towards the safe heaven regions. The Euro depreciated significantly against the U.S. dollar, while Eastern

currencies nearly collapsed. While the Euro was not on its best days, the Czech Koruna, Polish Zloty, and Russian Ruble faced consecutive devaluation (Chortane & Pandey, 2022). On the other hand, Akarsu and Gharehgozli (2024) studied the effects of the Russia-Ukraine war on the Polish Zloty, Hungarian Forint, Czech Koruna, Swedish Krone, and Romanian Leu. Their research highlights the individual impact of the war on these currencies, shaped by their distinctive political, economic, and financial frameworks. In a study by Aliu et al. (2024), the currencies of the V4 countries (Czech crown, Polish zloty, and Hungarian forint) were analyzed from February 1, 2022, to February 1, 2023. Their study indicates that the currencies of these countries were prevented from further crashing due to Russian gas payments being made through German contractors in Euros. The outbreak of war in Ukraine mainly exposed fragile democracy, with weak institutions and heavy reliance on Russian energy resources (Hossain et al., 2023). Notably, the financial systems in these countries faced tremendous difficulties with national currencies under constant devaluation. The importance of the Ruble recurred when the Russian president demanded that gas payments be made in Rubles. In this context, Aliu et al. (2022) argue that the Russian Ruble has played a decisive role in the euro devaluation. The imposed sanctions have made it impossible for the Russian Central Bank to intervene in the FX market. Financial institutions in the EU have kept a limited number of rubles due to its irrelevance in international trade. As a result, the limited supply of rubles and the increasing demand due to gas payments have repositioned it in the FX market. Western countries were aware that this war included not only geopolitical dimensions. First is the food crisis since Russia and Ukraine are considered the world's food granary. Second, the Russian natural gas supply (and oil to some extent) was vital for several EU member states. Third, a mandatory demand is for Russian gas to be paid in rubles. Considering all these successive events, our study modestly adds dimension to this ongoing conflict. Accepting that gas, oil, Wheat, corn, and the Ruble have been essential for the EU, we have analyzed their impact on the FX market. More specifically, they have generated spillover effects for the Czech Koruna, the Polish Zloty, the Hungarian Forint, and the Swedish Krona.

Our study employs Time-Varying Parameter Vector Autoregressions (TVP-VAR) incorporating improvements by Antonakakis et al. (2020). TVP-VAR offers distinct differences over previous studies utilizing quantile-to-quantile regression, wavelet coherence, and standard VAR techniques. In contrast to the standard VAR model, the TVP-VAR model allows coefficients to change over time according to a specified law of motion. Motivated by the sensitivity of the FX market during periods of non-economic shocks, we delve into this matter, primarily focusing on the Russia-Ukraine war and COVID-19. The study underscores the significance of gas, oil, Wheat, corn, and the Russian Ruble for the FX pairs under examination. Notably, the mandatory gas payments in Rubles and fluctuations in energy and agricultural commodity prices are identified as sources of devaluation for the Czech krona, Polish zloty, Hungarian forint, Swedish krona, Bulgarian lev (Bgn), Danish krone (Dkk), Romanian leu (Ron), Ukrainian hryvnia (Uah), and Turkish Lira. Furthermore, the contribution brings the dilemma of whether Western sanctions are the right political tools and subsequently have reached the desired effects. It explores the possibility that what is no longer sourced from Russia is being obtained from other countries, often with products (i.e., gas and other commodities) originating from Russia, which allows the Russian Ruble to remain in play. This underscores that the policy orientation may have yet to produce teachable effects as price volatility and exchange rates alter the direction.

Section 2 provides a literature review, Section 3 explains the research methodology, detailing both data collection and the model specification, and Section 4 presents the study's

results. Finally, Section 5 summarizes the conclusions, offering insights and implications from our research findings.

2. Literature review

Exchange rate movements are subject to the state of the trade balance, capital movements, central bank, and political actions. The COVID-19 pandemic and the war in Ukraine documented that the currency crash could also be of non-economic origin. Consequently, central banks protected the financial system's illiquidity with the currency devaluation costs. On the other hand, the war in Ukraine put the Euro and the non-euro members under continuous devaluation pressure. Capital flights as a reaction to the possible Russian invasion of the EU territory might remain a primary motive. This section emphasizes the influence of the Russia-Ukraine war, COVID-19, and a period of general stability on the ten European currency pairs. The research highlights the role of commodities and geopolitical context in shaping their market position. An early study by Humphreys (2005) suggests that heavy reliance on natural resources might lead to violence through rebel greed. This view precedes the recent conflicts but provides a foundational understanding of how resources can drive the FX market. Recent work by Bertaut et al. (2023) analyzed the dominant role of the U.S. dollar during COVID-19 and the Russian-Ukraine war. Their findings indicate that geopolitical events maintain a significant impact on currency pairs. Furthermore, studies by Aliu et al. (2022) and Xu et al. (2023) analyzed an interdisciplinary approach to the consequences of the Russian invasion of Ukraine. In short, Aliu et al. (2022) explored the impact of this war on Euro exchange rates, particularly against the Russian Ruble. Their findings reveal the Russian Ruble's significant influence on the devaluation of the Euro. At the same time, they highlight the sensitivity of the European financial system to external shocks like the war in Ukraine. This suggests that the immediate impacts of geopolitical events may be more pronounced in specific currency pairs, reflecting the interconnected nature of the FX market. On the other hand, Chortane and Pandey (2022) examined how the global currency market, especially in Europe and the Pacific, responded to war. They found that European currencies, notably the Russian Ruble, Czech koruna, and Polish zloty, depreciated due to the war and related sanctions. Even so, Pacific currencies appreciated, while Middle Eastern and African currencies were largely unaffected. Concurrently, Xu et al. (2023) considered the Russian-Ukraine war's effect on exchange rates, offering an in-depth analysis of the economic costs of the war. They argue that counterfactual predictions are reliable for assessing the magnitude of such geopolitical shocks. A study by Martins et al. (2023) examined the immediate impact of the Russian aggression on Ukraine on Europe's largest 100 listed banks. Their findings indicate that foreign banks with substantial ties to the Russian economy experienced a pronounced impact on their stock prices. This suggests that the crash in equity stocks was not uniform across all international banks but linked to internal characteristics. Bossman et al. (2023a) conducted a comprehensive analysis of economic policy uncertainty, geopolitical risk, and market sentiment across various EU sectors using data from February 2013 to September 2022. Their findings underscore the significant predictive power of EU economic policy uncertainty on sectoral stock returns within the EU, surpassing the effect of the U.S. economic policy uncertainty. Another research by Bossman et al. (2023b) employed quantile-on-quantile regression to investigate the asymmetric effects of oil, market volatility and sentiment,

economic policy uncertainty, and geopolitical risk on agricultural commodities. The results demonstrate that crude oil does not provide a reliable hedge or safe haven for agricultural commodities. Zhou et al. (2023) document the broader implications of war on food security and energy issues. Hence, they analyzed the correlation between armed conflicts and food insecurity, using the war in Ukraine as a case study. It emphasizes how non-economic shocks disrupt food insecurity and international food aid. They argue that ending the Russia-Ukraine war is necessary to prevent further exacerbating global food security issues. Inflation during this period was an additional concern for the policymakers. A study by Bouri et al. (2023) traces inflation spikes across several countries during the Russian invasion of Ukraine. They emphasize the important role of central banks in cooling inflationary pressures. The research by Raza et al. (2024) focused on the impact of the Russia-Ukraine conflict on precious metals and major currencies. Their study found that geopolitical risk significantly influences the interconnectedness between metal prices and currency pairs during inflationary spikes. Additionally, Tien et al. (2024) extended this analysis to cryptocurrencies and DeFi markets, indicating a shift towards newer financial instruments and their behavior during crises. Furthermore, Khan et al. (2023) emphasized how geopolitical risks and conflicts like the Russia-Ukraine war affect various aspects of the economy, from stock market returns to energy market volatility. They highlight geopolitical events' complex and far-reaching impacts on global financial stability. Umar et al. (2023) utilized wavelet coherence to investigate how the Russian-Ukrainian conflict affects sectoral shorted stocks. Their findings demonstrate a robust connection between shorted stocks and geopolitical shocks.

The following reviewed studies comprehensively understand the dynamics between forex markets and energy commodities. Rehman et al. (2022) explored the coherence and spillover between 30 forex exchanges during the COVID-19 pandemic. Employing the quantile cross-spectral and network connectedness approaches, they found significant long-term interdependence among currency exchanges worldwide. Similarly, Thai Hung (2023) explored the causality and price spillover effects between crude oil and exchange rate markets in G7 economies during COVID-19 and the Russia-Ukraine crises. Their study found a time-varying causality between exchange rate returns and oil prices, with crude oil prices significantly influencing the forex market. On the other hand, Bossman et al. (2023c) tracked oil (WTI), volatility (OVX), geopolitical risk (GPR), and sentiment (VIX) on EU sectoral stocks. Their findings, covering the period from January 2020 to October 2022, conclusively highlight that WTI, OVX, VIX, and GPR asymmetrically predict sectoral stock returns from the EU. Likewise, Hanif et al. (2023) focused on the relationship between precious metals futures and leading currencies before and during COVID-19. Using time-varying-parameter copula and Co-VaR methods, they indicate that the Australian dollar maintains the most significant spillover transmission on precious metals. Furthermore, Shaikh and Huynh (2022) examined the impact of COVID-19 on global equity, commodities, and FX markets, particularly regarding investors' fear index. They found that COVID-19 induced greater fear in the equity segment and significantly affected crude oil prices. In addition, research by Tanin et al. (2021) employed the nonlinear autoregressive distributed lag method to analyze the relationship between leading currency exchange rates and gold prices. Their findings suggest that gold acted as a safe-haven asset during COVID-19, highlighting the importance of gold compared to forex. So far, it is clear that the Russian-Ukraine war and the COVID-19 pandemic affect market participants and maintain far-reaching impacts on global currency pairs.

The International Grains Council (2023) has highlighted that the combined exports of barley and Wheat from Russia and Ukraine make up nearly 32% of the world's total supply. Specifically, in 2022, they exported 117 million metric tons out of the global total of 365 million metric tons, underscoring their critical role in global food security. At the same time, both countries remain critical players in the world production of corn, sunflower oil, and barley (Ben Hassen & Bilali, 2022). During 2022, the World Food and Agriculture Organization [FAO] (2022) recorded an unprecedented 17.1% increase in the Food Price Index (FPI). The global price of Wheat and corn surged because of export restrictions imposed on Russia. Additionally, the ongoing war has hampered Ukraine's ability to export. These two agricultural commodities and others have driven inflation in 2022. For instance, according to the World Bank, wheat prices increased 25% in the first quarter of 2022 alone, significantly contributing to the inflationary pressures. This, in turn, led to a decrease in the value of the national currency, as high inflation directly impacts national currency devaluation. Several EU members' dependency on Russian gas and oil is a significant concern. The recent decree by the Russian president mandating gas payments in rubles for the "unfriendly list of countries" only exacerbates this already critical situation (CNN, 2022). The following list includes nearly all countries (except Turkey) whose currencies are addressed in this study. The prices of oil, gas, corn, Wheat, and the Russian Ruble have significantly influenced the pressures on the FX pairs being studied. This underscores the significance of our study. Considering all these circumstances and others, our study differs from the previous ones as follows. First, include a more significant number of currency pairs under investigation. Second, it contextualizes the problem by including agricultural and energy commodities. Third, it involves mainly EU members with energy dependence on Russia and geographical proximity to the conflict zone.

3. Methodology

3.1. Data

This paper examines the impact of the Russia-Ukraine war, which stemmed from Wheat, corn, oil, and gas, on foreign exchange (FX) rates. For this purpose, we analyze the volatility spillovers generated from the Russian Ruble (Rub), natural gas (N. Gas), crude oil (Cr. Oil), Wheat, and corn (F. Corn) on the Czech krone (Czk)), the Polish zloty (Pln), the Turkish Lira (Try), the Hungarian forint (Huf), the Bulgarian lev (Bgn), the Danish krone (Dkk), the Romanian leu (Ron), the Ukrainian hryvnia (Uah), and the Swedish krone (Sek). The data was collected and prepared using R studio's "quantmod" package. The Euro is a benchmark pair since the countries under study (Czech Republic, Sweden, Poland, Hungary, Bulgaria, Romania, Denmark, Ukraine, Russia, and Turkey) maintain intensive economic relations with the Eurozone. Moreover, all these countries, except Turkey, Ukraine, and Russia, are European Union member states. Subsequently, 20% of transactions and international trade are conducted in Euro (Bank for International Settlements [BIS], 2022).

The outbreak of the Ukraine war significantly impacted the global economy. The rapid and unpredictable developments in foreign exchange and the commodity market were evident. At the same time, successive Western sanctions in retaliation against Russia hardly influenced Euro and non-eurozone currency pairs. On the other hand, agricultural and energy commodity prices experienced substantial hourly fluctuations. For this purpose, our study uses a daily series to convey all these events and their effects in real-time.

Table 1. Summary statistics based on the daily frequencies (source: authors' elaboration)

	N	Mean	Sd	Min	Max	Range	Skew	Kurt	JB-test	ADF	PP	KPSS
EUR/RUB	417	0.00	0.06	–0.73	0.77	1.50	0.71	116.7	0.00	0.01	0.01	0.1
EUR/CZK	417	0.00	0.00	–0.02	0.02	0.04	0.01	3.60	0.00	0.01	0.01	0.1
EUR/TRY	417	0.00	0.01	–0.04	0.06	0.11	0.98	6.07	0.00	0.01	0.01	0.1
EUR/HUF	417	0.00	0.01	–0.03	0.03	0.06	0.16	9.49	0.00	0.01	0.01	0.1
EUR/PLN	417	0.00	0.00	–0.02	0.02	0.05	0.36	3.62	0.00	0.01	0.01	0.1
EUR/BGN	417	0.00	0.00	–0.01	0.01	0.02	0.04	33.9	0.00	0.01	0.01	0.1
EUR/UAH	417	0.00	0.01	–0.03	0.22	0.26	12.3	43.4	0.00	0.01	0.01	0.1
EUR/RON	417	0.00	0.01	–0.12	0.12	0.24	–0.09	88.5	0.00	0.01	0.01	0.1
EUR/DKK	417	0.00	0.00	0.00	0.00	0.00	0.29	4.25	0.00	0.01	0.01	0.1
EUR/SEK	417	0.00	0.00	–0.02	0.02	0.04	–0.04	1.97	0.00	0.01	0.01	0.1
WHEAT	417	0.00	0.03	–0.11	0.20	0.31	0.74	5.28	0.00	0.01	0.01	0.1
CORN	417	0.00	0.02	–0.18	0.08	0.26	–2.21	17.59	0.00	0.01	0.01	0.1
N. GAS	417	0.00	0.06	–0.30	0.38	0.68	0.12	5.83	0.00	0.01	0.01	0.1
C. OIL	417	0.00	0.03	–0.13	0.08	0.21	–0.46	1.38	0.00	0.01	0.01	0.1

Table 1 signifies descriptive statistics of ten variables based on daily logarithmic return. The series covers the period from January 1, 2022, to September 1, 2023. The highest volatility (Sd) stands for the Eur/Rub and Natural Gas (N. Gas), followed by Crude Oil (Cr. Oil) and Wheat. The kurtosis (Kurt) of 116.7 indicates the profound devaluation that the Ruble experienced in the early days of the Russia-Ukraine war. The kurtosis ranges between 1.38 and 116.7, while the series is positively skewed. The Jarque-Bera (J.B.) test highlights that selected variables do not hold a normal distribution (p < 5%). Ultimately, the unit root test (ADF, P.P., and KPSS) shows that the series is stationary at the level (I0). In the same way, Figure A1 in the Appendix denotes the data distribution through Box-Plots. The most prominent outliers during this period appeared in Eur/Rub with 48, followed by Eur/Czk with 32. The smallest outliers are represented by Eur/Sec of 8 and N. Gas of 7. The Ukrainian hryvnia did not experience a profound devaluation like the Russian Ruble despite the invasion. Ukraine's financial aid from the EU and the USA (European Commission, 2023a) did not allow the collapse of the hryvnia. Aid in hard currencies such as the Euro and the U.S. Dollar has kept the currency in a gradual devaluation. Earlier, the Bulgarian lev was pegged to the Deutsche Mark (1 DEM = 1 BGN), while at present, it is pegged to the Euro at the rate €1 = 1.95583 BGN. The allowed fluctuation of the Bulgarian lev against the Euro is ±15%, while that of the Danish krone is only ±2.25%. Despite this, according to the European Exchange Rate Mechanism (European Commission, 2023b) rules, these countries must keep their long-term interest rates harmonized with the ECB's. Although most non-eurozone members are part of ERM II, the adoption of the Euro has been suspended. According to the Euro barometer, confidence in adopting the Euro is fading due to the European sovereign debt crisis in 2011.

Figure 1 indicates the daily prices of ten asset classes, six of which are FX rates, and the rest are agricultural and energy commodities. The FX rates experienced tremendous devaluation in the first months of the war, while commodities spiked high. From February 24, 2024,

to March 10 of the same year, the Russian Ruble devalued nearly 68% toward the Euro. Two months later, it regained its lost value, and on May 1, 2022, started trading at 1:60. In the Russian Federation, appreciation against the Euro acted as a defense mechanism against inflation. There is extensive debate on the origins of the Ruble appreciation, but two have been highlighted mainly. First, the Russian Central Bank (RCB) sets the base interest rate at a level of 20% (Trading Economics, 2023). However, this action exclusively targeted inflation and not the exchange rate – second, strict control of remittances sent by Russian citizens.

The appreciated position of the Ruble in the FX market results from the following motives. One is that Russia cannot access the international financial markets, and RCB actions have been null on the Rubbles pairs. To this end, the lack of participation in the international financial system makes intervening in the FX market impossible. The appreciation comes mainly from the increased demand for Rubles in the FX market. In particular, the decree of the Russian president that the "unfriendly list of countries" must make gas payments in Rubles has been a turning point (Al Jazeera, 2023b). The Ruble does not belong to the hard currencies, meaning its quantity in the FX market was limited. To this end, when the demand for a restricted currency is overshot, the exchange rate appreciates.

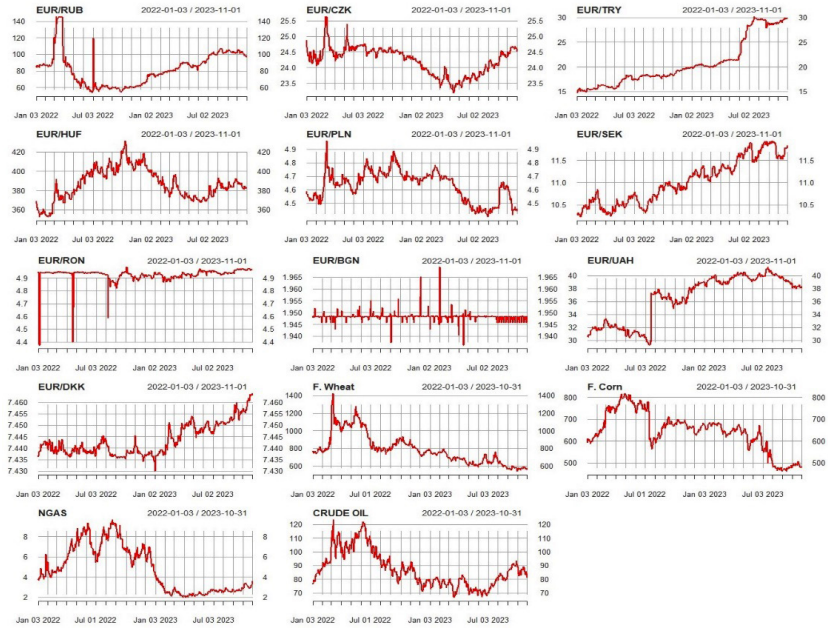

Figure 1. Closing prices of fourteen different asset classes (source: authors' elaboration)

This situation stood like this until November 2022, when the EU found other roots related to gas (LNG and Norwegian gas) and oil supply. From that time, the Russian Ruble began its subsequent devaluation, where on September 1, 2023, it was traded at 1:112 with the Euro. The natural question is why the Russian Ruble is not depreciating further. The main reason is that the demand for the Russian Ruble in the FX market still exists in Eurozone countries. One might be that Russia has identified loopholes to break Western sanctions (Le Monde, 2023). On the other hand, efforts to conduct trade relations with India using rupees have failed (Reuters, 2023).

3.2. Model specification

The TVP-VAR dynamic connectedness technique is implemented based on Diebold and Yilmaz (2012, 2014) and Antonakakis et al. (2020). The dynamic total connectedness framework stands on generalized forecast error variance decomposition (GFEVD). The variance decomposition is performed based on H-steps ahead and an optimal number of autoregressive lags. The TVP-VAR coefficients within the system of equations can change over time (Lubik & Matthes, 2015; Zhao & Zhang, 2023). The standard TVP-VAR model can take the following form:

$$y_{it} = \sum_{j=1}^{10} a_{ijt} y_{jt-1} + u_{it}, \tag{1}$$

where y_{it} denotes the position of variable i at time t, while ranges from 1 to 10 for the respective inputs in the system [i.e., y_{1t}: *Eur/Czk (Czech Krona)*, y_{2t}: *Eur/Huf (Hungarian Forint)*, y_{3t}: *Eur/Pln (Polish Zloty)*, y_{4t}: *Eur/Rub (Russian Ruble)*, y_{5t}: *Eur/Sek (Swedish Krona)*, y_{6t}: *Eur/Try (Turkish Lira)*, y_{7t}: *Eur/Bgn (Bulgarian Lev)*, y_{8t}: *Eur/Dkk (Danish krone)*, y_{9t}: *Eur/Ron (Romanian Leu)*, y_{10t}: *Eur/Uah (Ukrainian hryvnia)*, y_{11t}: *N. Gas (Natural Gas Prices)*, y_{12t}: *C. Oil (Crude Oil Prices)*, y_{13t}: *Wheat (Wheat Price), and* y_{14t} *Corn (Corn Prices)]*. The a_{ijt} indicated the time-varying parameter of input j reflecting the shock to input i at time t. On the other hand, y_{jt-1} stands for the variable j at time $t-1$. Finally, u_{it} demonstrates the error term for variable i at time t. In addition to the procedures for implementing TVP-VAR, stability, and unit root tests have been performed. Unit root tests such as Augmented Dickey-Fuller (ADF), Phillips-Perron (P.P.), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) verify the stationarity of the series. The system's lags were determined using information criteria such as the Akaike Information Criterion (AIC) and Schwarz or Bayesian Information Criterion (SIC or BIC). The stands' VAR is arranged considering the limited time series in the system that explains the combined dynamics of the variables through their lags. The TVP-VAR model can also be expressed as follows:

$$y_t = \beta_t Z_{t-1} + \in_t;\ \in_t | F_{t-1} \sim N\left(0, S_t\right); \tag{2}$$

$$vec(\beta_t) = vec(\beta_{t-1}) + v_t;\ v_t \mid F_{t-1} \sim N\left(0, R_t\right), \tag{3}$$

where y_t together with Z_{t-1} indicate the $N\times1$ and $N_p x1$-dimensional vectors. The time-varying coefficient matrix stands for $N\times N_p$ and β_t while the $\dot{o}_t$ and $N\times1$ error disturbance vector. On the other hand, $vec(\beta_t)$ and $vec\ (\beta_{t-1})$ highlight the $N^2p\times1$-dimensional vector while the $N^2p\times N^2p$ together with the R_t dimensional matrix. However, to compute generalized impulse response function (GFEVD) and variance decomposition, VAR must be transformed into a vector moving average, such as:

$$y_t = \sum L' W_t^j L_{\in_{t-j}};\ \tag{4}$$

$$y_t = \sum A_{it} \in_{t-j}, \tag{5}$$

where $L = \left[I_N, \ldots, 0_P\right]'$ stands for the $N_p \times N$ dimensional matrix while $W = \left[\beta_t; I_{N(p-1)}, I_{N(p-1)-N}\right]$ is an $N_p \times N_p$ dimensional matrix with A_{it}. On the other hand, TVP-VAR has an identical structure but is also based on the coefficients as stochastic processes. The GIRFs illustrate

how all variables react to a shock in variable *i*. Without a structural model, we determine the variances between a step-ahead forecast with a shock to the variable *i* and a forecast without the shock. However, the main issue in implementing TVP-VAR is conducting interference. The parameters of TVP-VAR stand on the linear VAR, but the model's overall structure is nonlinear. LASSO VAR and Quantile VAR were simultaneously applied to see the robustness of the findings from TVP-VAR. The findings (tables and connectedness plots) from LASSO VAR and Quantile VAR are available on request.

4. Results and discussions

The results based on TVP-VAR estimations are divided into two parts. Section 4.1 analyzes table connectedness and related plots (*From*, *to*, and *Net Connectedness*). Section 4.2 contains dynamic pairwise connectedness plots based on colored nodes.

4.1. Table connectedness results

This study examines the influence of crude oil, natural gas, Russian Ruble, Wheat, and corn on the Czech krona, Polish zloty, Hungarian forint, Swedish krona, Ukrainian hryvnia, Romanian Leu, Danish krone, Bulgarian Lev, and Turkish Lira. The TVP-VAR estimations were conducted considering one lag (*nlag* = 1), 200 rolling window size (*n* = 200), and for the ten periods ahead (*nfore* = 10). The model shows whether the inputs in the system are interconnected, the time frame, and the magnitude of connectedness. Tables 2, 3, and 4 present TVP-VAR estimations related to the Russia-Ukraine war, COVID-19, and a 2018/19 stability period. Table 2 highlights that 30.9% of the GFEVD can be attributed to the variables under study. On the other hand, for Table 3, the GFEVD for the period is 33.99%, while for Table 4, it stands at 35.22%. During the war in Ukraine, the variables in the system maintained the lowest level of interconnectivity, while the highest level was maintained during the stability period.

Table 2 (Model A) indicates TVP-VAR results during Russia-Ukraine covering the period from January 1, 2022, to September 1, 2023. *To-Connectedness* ranges between 12.54% (N. GAS) and 51.98% (EUR/HUF), while *From-Connectedness* is between 19.87% (N. GAS) and 40.93% (EUR/HUF). Russian Ruble appears as the net volatility transmitter with 12%, followed by the Hungarian forint with 11.05%, and the Czech krona with 7.72%. Other inputs, such as the Turkish Lira, Danish Krone, Romanian Leu, Bulgarian Lev, Ukrainian Hryvnia, N. Gas, Wheat, and Corn, remain net receivers. In short, the Russian Ruble has been the net transmitter of risk spillover to almost all other variables in the system.[1]

Although the paper emphasizes the Russia-Ukraine war, the study further delves into a comparison with the COVID-19 pandemic and a stability period. Table 3 (Model B) presents the TVP-VAR result during COVID-19, covering the period from January 1, 2020, to September 1, 2022. The total connectedness is higher during COVID-19 (33.9%) than during the Russia-Ukraine war (30.9%). This is mainly because the character of these two non-economic shocks differs in origin and scope. The regional, cultural, and economic characteristics of connectedness are pronounced during this period. The importance of the Russian Ruble based

[1] To verify our estimations' robustness, we reduced the number of rolling windows to 100 and the steps ahead to 5 (*H* = 5). Despite shortening the rolling window and steps ahead, the results remain unchanged. The robustness checks were conducted for three periods under study (Russia-Ukraine war, COVID-19 pandemic, and stability period). Simultaneously, we have performed LASSO VAR and Quantile VAR (QVAR) and considered identical inputs in the system. Estimations through LASSO and QVAR align with those of TVP-VAR, with minor differences in agricultural commodities. All results (plots and tables) are available on request.

Table 2. TVP-VAR Connectedness results during the Russia-Ukraine war (source: authors' elaboration)

Model A	EUR/ CZK	EUR/ HUF	EUR/ PLN	EUR/ RUB	EUR/ SEK	EUR/ TRY	EUR/ BGN	EUR/ UAH	EUR/ RON	EUR/ DKK	N. GAS	C. OIL	WHEAT	CORN	From (*j*)
EUR/CZK	63.2	7.39	4.55	4.45	4.00	1.17	1.79	1.18	3.49	3.40	1.45	1.11	1.39	0.88	36.78
EUR/HUF	6.52	59.1	15.3	3.76	3.62	1.05	1.65	1.23	0.96	1.80	1.75	1.46	0.49	1.38	40.93
EUR/PLN	4.32	15.8	60.1	2.69	6.97	0.85	1.20	1.46	0.94	1.33	0.54	1.57	1.55	0.67	39.88
EUR/RUB	1.36	0.85	3.93	80.7	0.32	1.47	1.19	0.81	0.84	4.24	0.52	1.98	0.55	1.22	19.28
EUR/SEK	3.92	4.77	7.94	3.17	68.7	1.90	0.62	1.09	0.89	1.33	0.71	1.04	1.64	2.33	31.35
EUR/TRY	6.09	4.95	3.00	3.91	1.83	62.1	2.08	1.25	9.38	0.96	0.79	1.30	0.52	1.93	37.98
EUR/BGN	1.62	3.54	3.13	8.28	0.49	1.21	73.6	0.67	0.87	2.02	1.04	1.38	0.71	1.44	26.40
EUR/UAH	2.26	1.51	1.08	2.05	0.69	2.43	0.90	81.9	2.77	0.67	0.81	0.92	0.80	1.20	18.09
EUR/RON	4.23	3.75	0.57	2.07	0.44	9.38	1.46	2.51	71.2	1.69	0.70	1.09	0.38	0.57	28.84
EUR/DKK	4.85	2.02	1.74	6.88	0.72	0.90	2.32	1.63	1.74	72.8	0.54	1.55	1.04	1.17	27.25
N.GAS	2.39	2.62	0.97	1.96	1.07	1.63	1.29	1.45	1.60	0.96	80.1	2.39	0.87	0.68	19.87
C. OIL	1.75	1.63	1.88	2.85	1.87	1.57	1.52	1.07	1.29	1.22	2.16	69.5	4.23	7.41	30.44
WHEAT	4.29	1.26	1.90	2.80	1.12	1.16	0.86	0.94	1.47	1.13	0.98	4.68	61.4	16.0	38.62
CORN	0.90	1.36	0.78	3.44	1.19	1.07	1.58	1.37	0.82	0.68	0.39	7.18	16.3	62.9	37.04
To (*i*)	**44.51**	**51.98**	**46.71**	**48.30**	**24.33**	**25.80**	**18.46**	**16.65**	**27.06**	**21.40**	**12.54**	**27.64**	**30.45**	**36.93**	**432.76**
Inc. Own (T.C.)	**107.7**	**111.1**	**106.8**	**129.1**	**92.98**	**87.82**	**92.06**	**98.65**	**98.22**	**94.16**	**92.67**	**97.21**	**91.83**	**99.82**	**1400.3**
Net	**7.72**	**11.05**	**6.82**	**12.00**	**3.00**	**–6.00**	**–7.94**	**–1.44**	**–1.78**	**–5.84**	**–7.33**	**–2.79**	**–8.17**	**–0.16**	**30.9%**

Table 3. TVP-VAR Connectedness results during COVID-19 (source: authors' elaboration)

Model B	EUR/ CZK	EUR/ HUF	EUR/ PLN	EUR/ RUB	EUR/ SEK	EUR/ TRY	EUR/ BGN	EUR/ UAH	EUR/ RON	EUR/ DKK	N. GAS	C. OIL	WHEAT	CORN	From (*j*)
EUR/CZK	47.8	13.5	17.8	3.39	4.93	0.96	1.88	1.61	2.18	0.41	1.38	1.92	1.03	1.13	52.17
EUR/HUF	15.1	50.7	15.3	1.33	2.27	0.68	0.80	2.38	1.06	1.07	1.74	2.77	2.14	2.62	49.04
EUR/PLN	18.1	14.5	49.5	2.26	4.20	1.01	1.09	1.02	1.11	0.57	1.45	1.88	1.80	1.58	50.52
EUR/RUB	3.61	1.09	2.58	61.9	11.2	8.82	1.25	0.85	1.56	1.15	1.61	1.15	1.27	1.94	38.10
EUR/SEK	6.57	2.65	5.25	11.4	60.3	1.57	2.51	1.50	1.21	0.89	0.95	2.78	1.13	1.15	39.74
EUR/TRY	2.29	1.34	1.88	9.98	1.61	70.1	2.48	1.47	0.77	1.19	1.36	3.49	1.12	0.92	29.90
EUR/BGN	3.31	0.87	1.09	2.50	1.89	2.84	73.7	1.57	2.39	2.41	1.14	3.11	1.00	2.17	26.29
EUR/UAH	2.77	3.48	2.78	3.38	1.24	1.51	2.25	68.1	3.56	1.65	2.35	2.82	0.85	2.61	31.89
EUR/RON	2.93	2.05	4.14	1.63	1.00	0.54	2.14	3.69	74.9	0.53	1.68	1.83	0.95	1.98	25.10
EUR/DKK	0.90	2.04	1.32	2.04	1.72	1.58	1.92	1.12	2.08	77.7	1.57	2.15	2.82	1.05	22.31
N.GAS	0.62	2.55	1.77	1.38	1.25	0.78	0.60	1.37	0.91	0.81	79.0	2.48	2.26	4.22	21.00
C. OIL	1.30	0.87	0.89	0.46	0.48	0.91	2.14	1.07	0.92	0.66	1.92	85.7	0.77	1.86	14.25
WHEAT	2.09	3.34	2.88	0.96	1.38	0.92	1.48	1.93	1.86	1.94	2.51	3.05	61.49	14.2	38.51
CORN	1.00	3.03	3.10	1.56	0.67	1.01	1.06	2.08	1.54	0.68	5.85	1.81	13.7	62.9	37.06
To (*i*)	**60.69**	**51.40**	**60.64**	**42.72**	**33.87**	**23.13**	**21.61**	**21.67**	**21.23**	**13.96**	**25.51**	**31.27**	**30.79**	**37.40**	**475.89**
Inc. Own (T.C.)	**108.5**	**102.4**	**110.1**	**104.6**	**94.12**	**93.23**	**95.32**	**89.78**	**96.14**	**91.64**	**104.5**	**117.0**	**92.28**	**100.3**	**1399.9**
Net	**8.52**	**2.36**	**10.12**	**4.62**	**–5.88**	**–6.77**	**–4.68**	**–10.22**	**–3.86**	**–8.36**	**4.51**	**17.01**	**–7.72**	**0.35**	**33.99%**

Table 4. TVP-VAR Connectedness results during the stability period 2018-2019 (source: authors' elaboration)

Model C	EUR/ CZK	EUR/ HUF	EUR/ PLN	EUR/ RUB	EUR/ SEK	EUR/ TRY	EUR/ BGN	EUR/ UAH	EUR/ RON	EUR/ DKK	N. GAS	C. OIL	WHEAT	CORN	From (*j*)
EUR/CZK	58.8	8.81	10.9	0.77	3.61	2.65	2.46	2.58	1.60	2.12	1.20	2.18	0.85	1.42	41.18
EUR/HUF	7.11	51.1	15.9	0.56	4.07	3.20	2.04	3.31	3.70	3.41	1.62	1.54	0.70	1.61	48.86
EUR/PLN	7.78	14.3	45.3	1.38	4.83	2.38	3.00	4.68	4.46	4.19	3.33	1.91	0.58	1.89	54.72
EUR/RUB	1.07	0.99	2.49	71.5	2.38	7.65	1.78	2.40	1.49	1.42	1.06	2.17	1.44	2.09	28.45
EUR/SEK	2.79	3.92	6.04	1.50	61.7	2.68	2.89	5.40	3.57	2.93	1.84	2.03	1.05	1.66	38.30
EUR/TRY	1.73	3.14	1.18	6.88	1.55	78.6	0.58	0.98	0.87	1.24	0.34	0.81	0.78	1.29	21.38
EUR/BGN	2.04	1.86	3.45	1.16	2.48	2.28	63.1	4.30	2.89	6.69	3.44	2.48	0.85	3.01	36.94
EUR/UAH	2.98	4.34	5.86	1.75	5.25	1.62	3.10	57.2	3.96	3.68	3.28	2.00	1.78	3.14	42.76
EUR/RON	1.03	4.15	5.13	0.65	3.41	2.01	2.93	3.79	63.9	6.52	1.61	0.98	1.00	2.85	36.08
EUR/DKK	1.47	4.00	4.11	0.63	2.16	2.65	4.59	3.95	5.06	63.7	3.20	1.14	0.88	2.46	36.32
N.GAS	0.96	2.74	3.60	2.07	1.77	1.40	2.79	3.90	2.32	4.62	69.1	2.36	1.07	1.32	30.92
C. OIL	2.62	1.51	2.60	2.57	3.57	3.18	2.74	2.11	2.21	1.17	2.27	69.9	1.62	1.94	30.11
WHEAT	1.16	2.14	1.56	0.86	1.73	1.38	1.31	2.15	1.69	1.54	1.32	1.38	59.9	21.8	40.05
CORN	0.82	1.35	1.90	0.98	1.49	1.80	2.89	4.02	2.91	2.16	1.81	0.56	20.1	57.2	42.83
To (*i*)	**33.57**	**53.26**	**64.82**	**21.76**	**38.32**	**34.88**	**33.11**	**43.58**	**36.73**	**41.69**	**26.33**	**21.54**	**32.77**	**46.53**	**528.89**
Inc. Own (T.C.)	**92.39**	**104.4**	**110.1**	**93.32**	**100.0**	**113.51**	**96.18**	**100.8**	**100.6**	**105.37**	**95.41**	**91.43**	**92.72**	**103.7**	**1499.9**
Net	**–7.61**	**4.40**	**10.10**	**–6.68**	**0.02**	**13.51**	**–3.38**	**0.82**	**0.65**	**5.37**	**–4.59**	**–8.57**	**–7.28**	**3.69**	**35.22%**

on *To-Connectedness* drops to 42.72% while that of the Hungarian forint, Polish zloty, and Czech krona increases. It is observed that the currencies of the V4 countries (Czech Republic, Poland, and Hungary) have a higher spillover effect than during the Russia-Ukraine war. In *To-Connectedness*, the Czech korona leads with 60.7%, the Hungarian forint with 60.4%, and the Polish zloty with 51.4%. It is worth noting that the *To-Connectedness* of the Ukrainian hryvnia increased from 16.6% during the Russia-Ukraine war to 21.6% during COVID-19. Also, the Turkish Lira and Swedish Krona received significant influence only from the Russian Rubles during this period. The Russian tourism in Turkey and the economic relations between the two countries might be the explanation. Compared to the Russia-Ukraine war, a slight increase in the weight of the importance of agricultural and energy commodities was emphasized.

Table 4 (Model C) presents the TVP-VAR estimation for the stability period from January 1, 2018, to September 1, 2019. Total connectedness was higher (35.2%) during the stability period than in the two previous periods under study (33.9% and 30.9%, respectively). The *To-connectedness* of the Russian Ruble fades to 21.7%, while the Polish zloty leads again with 64.8% and the Hungarian forint with 53.2%. It should be highlighted that during this period, the importance of the Ukrainian hryvnia increased to 43.5% compared to the two non-economic shocks. Corn and Wheat in the three periods (stability, COVID-19, and the Russia-Ukraine war) accept the influence only from each other and not from other inputs in the system. Spillover effects (*From* and *To-connectedness*) range between 21.8% and 14.2%.

Figures 2, 5 present *From* and *Net-connectedness* during the Russia-Ukraine war with daily logarithmic returns. Figure 2 (*Net-connectedness*) illustrates that most volatility spillover was generated during the first six months of the Russia-Ukraine war. This is also confirmed through Figure 5 (*From-Connectedness*), where the variables received most of the volatility transmission during this period. The exception is the Russian Ruble, which has performed unaffected by other variables. The Russian Ruble has absorbed limited influence from other variables but has been the primary volatility transmitter. Figure 5 displays that Ruble has distributed most of the effects to other variables in the system (*Net-Connectedness*). In summary, the Russian Ruble was playing the primary role in the gradual devaluation of the Polish zloty, Czech crown, Hungarian forint, and Bulgarian lev. This is mainly because the "unfriendly list" obliged countries in need to make gas payments in Rubles. The findings illustrate that even weak currencies (such as the Russian Ruble) can regain a crucial position within the FX market. Moreover, geopolitical context and energy dependence from authoritarian regimes could cause exchange rates to fall.

The results of our study are relevant not only to retail traders but also to policymakers. From a policy perspective, central banks must understand that national currencies may only sometimes adhere to economic shocks. In such scenarios, holding U.S. dollars and gold reserves could safeguard against devaluation, although it may not provide absolute protection. In the case of energy crises, such as the gas shortage in Europe and general global security issues, monetary policies may be less effective in protecting currencies from devaluation. On the other hand, Forex traders should be cautious because non-financial factors can also influence the value of FX pairs. Even relatively weak currencies like the Russian Ruble can gain a significant position based on the geopolitical context. Despite the contracts for Russian gas payments being in euros, the Ruble gained importance in the FX market following the Russian president's decree on the "unfriendly list of countries." This highlights the necessity for countries dependent on energy from a specific nation to hold reserves in that nation's currency alongside U.S. dollars, euros, or gold.

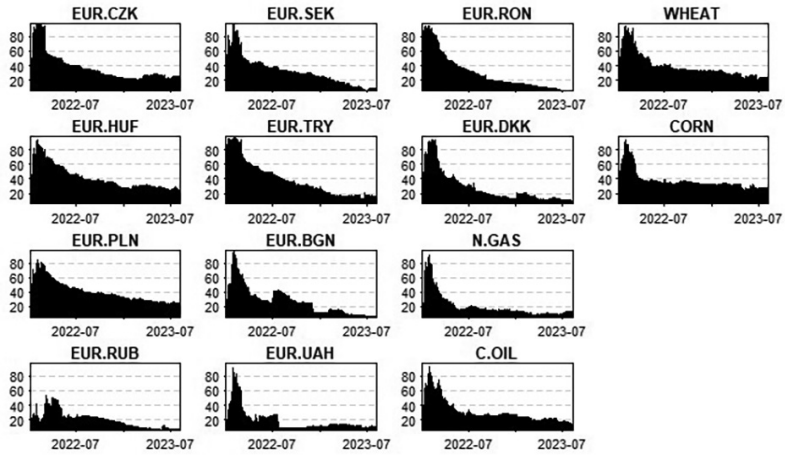

Figure 2. From-Connectedness plots during the Russia-Ukraine war (source: authors' elaboration)

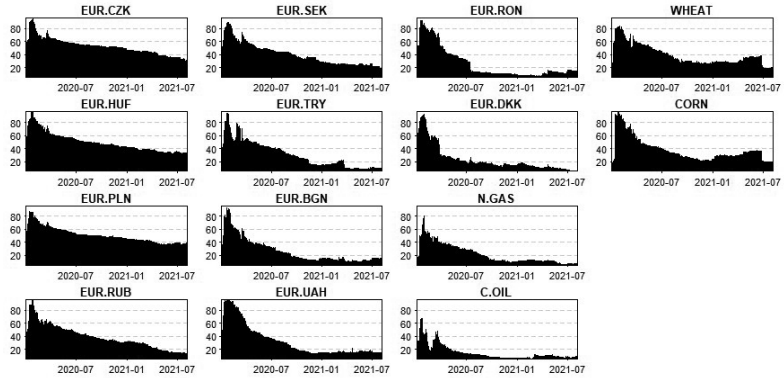

Figure 3. *From-Connectedness* plots during COVID-19 (source: authors' elaboration)

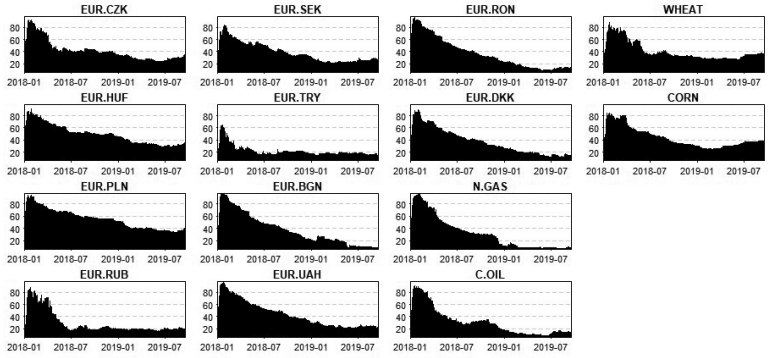

Figure 4. *From-Connectedness* plots during the stability period 2018–2019 (source: authors' elaboration)

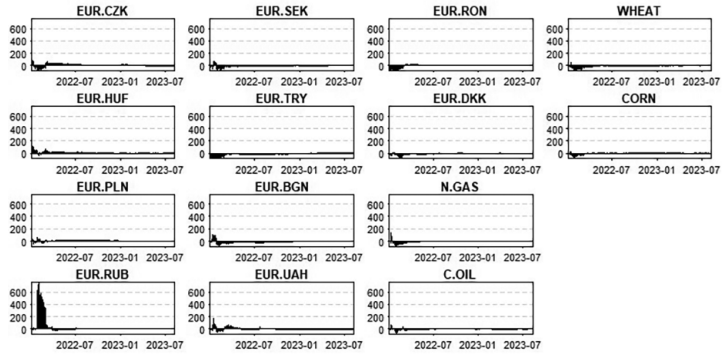

Figure 5. *Net-Connectedness* plots during the Russia-Ukraine war (source: authors' elaboration)

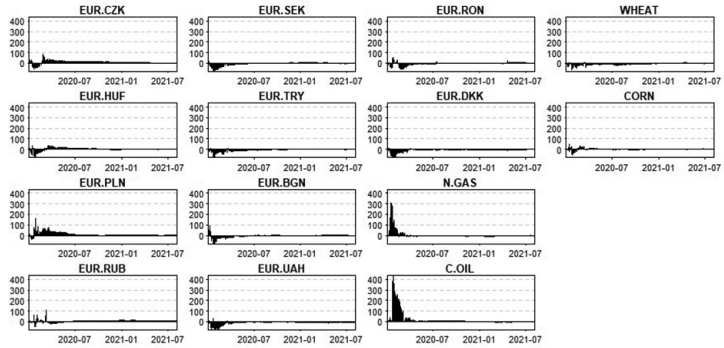

Figure 6. *Net-Connectedness* plots during COVID-19 (source: authors' elaboration)

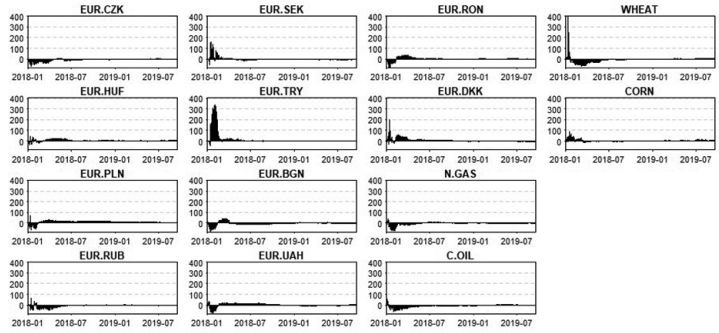

Figure 7. *Net-Connectedness* plots during the stability period 2018–2019 (source: authors' elaboration)

Figures 3 and 6 show TVP-VAR estimations (*From* and *Net-Connectedness*) covering the COVID-19 pandemic. *From-Connectedness* shows that natural gas and crude oil have had limited effects during this time. On the other hand, other inputs in the system have significantly affected currency pairs and agricultural commodities. Interesting to highlight is that Ruble absorbed higher spillover during this period compared to the Russia-Ukraine war. The stability period (Figure 4) indicates that all variables are more interconnected (*From-connectedness*) with others in the system.

Net-connectedness during the stability period (Figure 7) shows that the Turkish Lira (EUR/TRY) has been the primary risk transmitter. Bossman et al. (2023d) have underscored the Swiss franc and the Euro as effective hedges against geopolitical risk. Notably, our study's findings reveal that the currencies under consideration have experienced devaluation against the Euro. This evidence highlights the Euro's superior hedging capabilities within European currencies, supporting the findings of Bossman et al. (2023d). A recent study by Aliu et al. (2022) focused on the Euro's exchange rate compared to four other hard currencies. The study shed light on the impact of the Russia-Ukraine war on the Euro's devaluation against the Russian Ruble and the geopolitical factors at play. While the Euro was losing value against the U.S. dollar and other strong currencies, our research indicated that non-euro area currencies, including the Turkish Lira and the Ukrainian hryvnia, were also losing value against the Euro. This demonstrates the complex interplay of global events and currency dynamics, making it a critical area for further analysis and understanding. The currencies of EU countries near the war zone (Ukrainian territory) suffered a more pronounced devaluation than others. The study supports Aliu's et al. (2022) argument and emphasizes that the Ruble has significantly contributed to devaluing other non-eurozone currencies except the Euro.

4.2. Pairwise connectedness network plot

Figure 8 depicts return pairwise connectedness plots for three diverse periods (the Russia-Ukraine war, the COVID-19 pandemic, and the stability period). During the war in Ukraine, Ruble maintained a significant effect on the currency devaluation of countries with a heavy reliance on Russian gas. However, a critical part of the devaluation could be attributed to capital flights towards safe havens such as the USA. The Bulgarian lev, Czech krona, Polish zloty, Hungarian forint, and Swedish krona have received substantial spillover from the Russian Ruble.

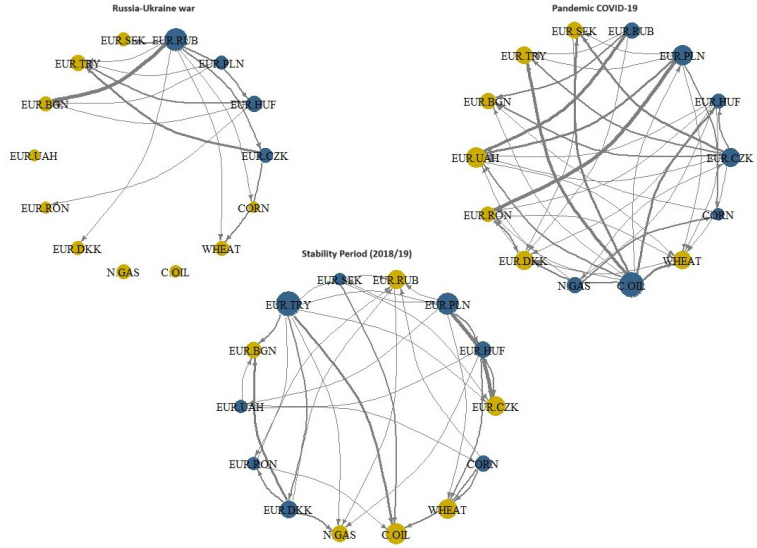

Figure 8. The dynamic connectedness network plot during the Russia-Ukraine war, COVID-19 pandemic, and stability period 2018–2019 (source: authors' elaboration)

Since the decree of the Russian president regarding the "unfriend list of countries," these countries have been obliged to make gas payments in rubles. At that time, the energy dependence of the Czech Republic, Poland, and Hungary ranges from 40% to 90%. On the other hand, in September 2022, Poland ended the deal to receive Russian gas (Reuters, 2022). This is due to the liquefied natural gas (LNG) produced at the Gdansk port. It is worth noting that the Russian Ruble did not influence the Ukrainian hryvnia during this period.

The dynamic network plot during COVID-19 emphasizes once again the importance of Ruble. However, during this period, the Net spillover of the Polish zloty, the Hungarian forint, the Czech crown, corn, crude oil, and natural gas. Due to worldwide stringency measures and the breakdown of supply chains, crude oil and corn spiked high. Regional influence is also present, where the currency pairs of the Visegrad countries (known as V4) generate a spillover effect among themselves. However, during the stability period (2018/19), the Turkish Lira appears as a significant net spillover in the system. These estimations can have practical grounds when considering Turkey's importance in world trade. However, since the outbreak of the COVID-19 pandemic, the Turkish Lira has experienced constant devaluation, accelerating during the war in Ukraine. The crash in the Turkish Lira was mainly due to inflation, which reached 72.3% at the end of 2022 (Trading Economics, 2023).

Central banks play a crucial role in shaping currency exchange rates. Their strategic interest rate adjustments, monetary policy decisions, and interventions in the forex market directly impact investor sentiment, capital flows, and the overall value of a country's currency. Although each central bank has different mandates, the European Central Bank [ECB] aims to keep inflation below 2% (ECB, 2024). In addition to inflation, central banks in the non-euro area also target unemployment and exchange rate stability. Central banks prioritize maintaining price stability as their primary goal. It is crucial to recognize that currency devaluation can lead to accelerated inflation and an increased burden of government debt denominated in foreign currency. Therefore, ensuring the currency's stability in the foreign exchange market is an indirect goal of central banks. The outbreak of the COVID-19 pandemic, as well as the Russian invasion of Ukraine, has led to frequent interventions by central banks. The COVID-19 pandemic was a global phenomenon, during which central banks focused more on maintaining the financial system's liquidity. The Russia-Ukraine war revealed that geopolitical tensions can significantly impact exchange rates. Capital flight to the USA, surging oil and gas prices, and investor panic contributed to financial capital's departure to the USA. The depletion of hard currency reserves from the European continent resulted in the depreciation of most currencies against the U.S. dollar, including the Euro.

5. Conclusions

The study investigated the impact of the Russia-Ukraine war and the COVID-19 pandemic on selected European currencies and critical commodities, offering valuable insights into the complexity of currency dynamics amidst geopolitical turmoil and global health crises. The application of the TVP-VAR method revealed significant interdependencies, with geopolitical decisions and energy dependencies playing crucial roles in currency valuation. The study findings emphasize the significant role of geopolitical decisions, particularly the influence of the Russian Ruble and energy dependencies on the valuation of European currencies. The study contributes to understanding the spillover effects of non-economic shocks on the FX market, highlighting the delicate interdependence between fiat currencies, geopolitical dynamics, and commodity dependencies. The theoretical implications of the study enrich the existing

literature on currency dynamics and the effects of geopolitical and health-related shocks on financial markets. Practically, our research aids policymakers and investors in understanding the potential risks and opportunities arising from turmoiled events. The limitations of our study include the scope of currencies and commodities analyzed, which may not capture the full spectrum of global market dynamics. Future research should consider broader variables, including more diverse geopolitical events and economic indicators, to provide a more comprehensive view of the global financial environment. Despite the efforts of central banks in EU member countries, the currencies have undergone a significant devaluation. It is evident that in situations of such substantial capital outflow, interventions have a limited impact on protecting exchange rates. The Turkish situation is unique. The war in Ukraine has significantly exacerbated the already soaring inflation. The consistent devaluation of the Turkish Lira, coupled with the impact of the war, has further weakened its position in the foreign exchange market. During this period, the Bulgarian leva and the Danish krone were pegged to the Euro and were under significant pressure. To keep their currencies stable, the central banks of these countries likely had to intervene in the money market with substantial amounts of Euros. These pressures on the Bulgarian lev and the Danish krone manifested as increased volatility during COVID-19, particularly in the first months of the war in Ukraine.

In future studies, intraday data could provide a more accurate and detailed representation of how the Russia-Ukraine war has affected the analyzed currency pairs. This approach would facilitate more direct effects between the developments on the ground and sanctions imposed on Russia. Moreover, including FX pairs of other countries with which Russia has intensive trade relations would be exciting. In conclusion, our research offers a nuanced perspective on the impact of the Russia-Ukraine war and COVID-19 on the FX market, emphasizing the importance of geopolitical context in shaping currency dynamics. The study's implications for theory and practice, alongside its limitations, pave the way for further investigation into the complex relationship between geopolitical events, currencies, and commodities in the global FX market.

Disclosure statement

The authors declare that they do not have any competing financial, professional, or personal interests from other parties.

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APPENDIX

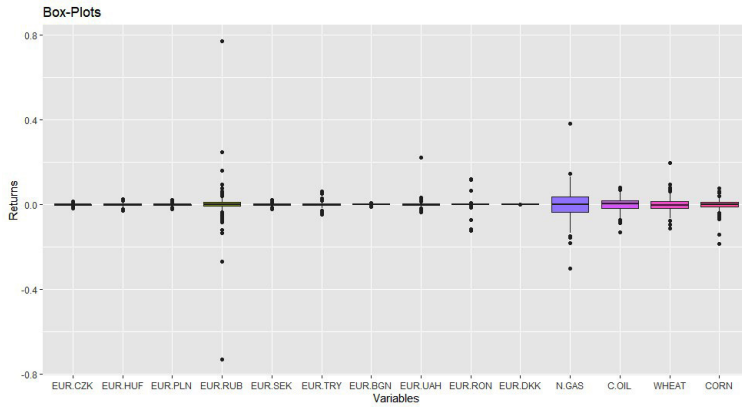

Figure A1. Data distribution through Box-Plots (source: authors' elaboration)